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Translation

BOOK EXCERPTS: AIR DEFENSE OF GROUND TROOPS

By

Yu. A. Andersen, A.I. Drozhzhin, and P.M. Lozik

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BOOK EXCERPTS: AIR DEFENSE OF GROUND TROOPS

Moscow PROTIVOVOZDUSHNAYA OBORONA SUKHOPUTNYKH VOYSK in Russian 1979 signed to press 17 Apr 79 pp 1-6, 71-79, 194-226, 269-299, 300-303

[Book by Yu. A. Andersen, A.I. Drozhzhin, P.M. Lozik, Voyenizdat, 23,000 copies, 304 pages]

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ANNOTATION, TABLE OF CONTENTS AND INTRODUCTION

Moscow PROTIVOVOZDUSHNAYA OBORONA SUKHOPUTNYKH VOYSK (Air Defense of Ground Troops) in Russian 1979 signed to press 17 Apr 79 pp 1-6, 71-79, 194-226, 269-299, 300-303

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[Excerpts] This book sets forth modern views on Air Defense of Ground Troops (ADGT) and it shows the offensive air threat, its combat employment and air defense forces. It discusses air defense in the Great Patriotic War and in local wars and it provides principles for organizing and conducting air defense in various types of army operations.

The book was written in a popular science style based on materials published in the domestic and foreign open press and it is designed for Soviet Armed Forces officers, students and cadets at military educational institutions and a broad group of readers.

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Introduction

While imperialism retains its aggressive nature and with the sharp exacerbation in its contradictions which are a fertile environment for capitalist nations to start wars, there is still an objective requirement to strengthen our Armed Forces.

Against the spirit of relaxation in the international environment, imperialist nations are continuing to build up their military strength and to modernize their armies. They are significantly increasing appropriations for new weapons and military hardware research and development, including strategic, tactical and army aviation aircraft, cruise missiles and other weapons.

They are increasing the number and scope of their strategic and tactical exercises where they work out procedures and methods of waging war againsst the socialist camp.

In this environment, the Communist Party and the Soviet Government, guided by the great Lenin's charge that "Any revolution is only worth something if it is able to defend itself,"* view the enhancement of the USSR's defense and the strengthening of the Armed Forces might as the entire

*Lenin V.I. "Poln. sobr. soch." (Complete Collected Works), vol 37, p 122.

nation's cause and as a most important governmental function. The new USSR Constitution points out that "The USSR Armed Forces duty to the people is to reliably defend the socialist homeland and to be in a permanent fighting trim which will guarantee an immediate defeat to any aggressor."*

The government guarantees the country's security and defense capability and it equips the USSR Armed Forces with everything they need.

The duties of governmental authorities, public organizations, officials and citizens in guaranteeing the country's security and strengthening its defense capability are set by law.

Recent years have been characterized by a revolution in military affairs, a revolution caused by technological progress.

Fundamental changes in weapons and military hardware are bringing about qualitatively new forms and methods of conducting operations and battles.

At present, all the developed capitalist countries' armies are devoting a great deal of attention to upgrading ADGT systems. They are developing new models and modernizing current models of air defense missile and artillery weapons, fighter interceptors and electronic equipment for intelligence, command and control and active jamming; they are searching for the most rational organizational structures and the most rational methods for their operations.

The steady increase in the role and importance of air defense is caused by the swift qualitative and quantitative growth of weapons which use the air space to penetrate the strike targets. Practically all types of airborne platforms can be weapons of mass destruction carriers; a significant part of them are used to deliver conventional weapons which greatly exceed the power of weapons employed in World War II.

It is well known that offensive weapons development has always been inseparably linked to weapons to counter them. The pithy saying about the competition between projectiles and armor is applicable here. To counterbalance offensive air weapons development, improvements are made to the air defense system.

Air defense defended assets include: the country's political and administrative centers, industrial installations, major cities and army and naval forces.

The special features of the Navy's air defense do not require any special explanation since the mission of shipborne air defense resources speaks for itself. For air defense of ground troops and its rear area assets..., the characteristic features are high mobility and a dynamic nature which is

*USSR Constitution (Basic Law), Moscow, Politizdat, 1977, p 15.

caused by army operations in contemporary fluid operations and battles; the depth is primarily limited to the Fronts' operational areas. These special features directly determine the nature of the missions accomplished by air defense forces.

The ground troop and front (tactical) aviation are earmarked for actions in ground theaters of operations in conjunction with the other armed services. The large strategic formations of modern armies have the appropriate air defense forces at their disposal; the composition and technical equipment of these forces are determined by the fact that theater-level and tactical, and only some strategic, enemy air operations can be anticipated against troop units and their rear areas.

Air defense is an integral part of ground troop operations. It is based on integrating operational employment of various forces, based on complex modern equipment, command, control and air intelligence systems and on using mathematical data processing methods.

Air defense forces are equipped with multirole, mobile air defense, missile systems, self-propelled multibarreled AAA, target surveillance radars and electronic command and control systems.

Modern air defense methods can only be mastered and the opportunities and procedures for implementing them in modern warfare can only be comprehended by understanding the principles of operational art and military technology which are being brought about by progress in science and technology, by critically mastering the experience of past wars and by skillfully transferring what is useful from this experience to contemporary reality.

In the contemporary environment, V. I. Lenin's instructions are especially appropriate: "...it is foolish or even criminal for an army not to master all the types of weapons, all the military weapons and tactics, which the enemy has or may have."* Therefore, it is necessary to closely follow the development of the art of war and military technology abroad while drawing the proper conclusions for our own practical activities to strengthen our homeland's defense power.

*Lenin, V. I. "Poln. sobr. soch.," vol 41, p 81.

Chapter One

Evolution of Air Defense of Ground Troops

4. Modern Views on the Air Battle

In the opinion of foreign military specialists, there are two basic forms of the air battle:

--destroying enemy offensive air weapons at their locations on the ground and at their locations in the open sea close to dry land (on submarines and surface ships) and destroying storage depots and production facilities;

--destroying airborne offensive air weapons enroute to designated strike targets and while conducting combat operations.

They believe that both types of combat against offensive air weapons are closely related and supplement each other; they are used in combination and are directed toward achieving a single goal--defeating the opposing side's air and missile forces.

The air battle is a job for all the Armed Services and the branch arms. However, their methods and ways of achieving the goal indicated are significantly different. The missile arm, air arm, artillery, submarines and surface ships are able to deliver strikes both against offensive air weapons before their launch (takeoff) from launch sites, airfields, aircraft carriers, helicopter carriers, at storage depots and on transports and against their production sites. Extremely effective, as shown by combat experience in World War II, were the strikes against command and control centers and electronic equipment. These strikes may result in a significant reduction in the enemy's capability to conduct raids.

Swift actions by combined arms formations and units, air and amphibious assault forces, reconnaissance and sabotage groups and partisan detachments to seize launch sites and airfields can significantly weaken the enemy's offensive air power.

Foreign military specialists assume that all offensive air weapons cannot be discovered and destroyed prior to their launch or takeoff, especially those which are dispersed over wide areas, concealed or camouflaged. Therefore, land forces must be able to effectively destroy the air threat in its flight routes (trajectories) in their air space.

According to the NATO concept, air defense (meaning the entire air battle) is divided into offensive and defensive. The first includes strikes to weaken the enemy's air and missile posture; the second includes defending forces and assets against air attack. Experience in recent local wars has confirmed on numerous occasions that preemptive strikes against offensive airbases established a more favorable environment to accomplish the mission of defending against them. The offensive air threat's ability to maneuver swiftly in the air space of a single theater of operations or between several theaters of operations will always require a highly combat-ready, maneuverable air defense system in being.

At present, there are various forces to accomplish the air defense mission. All the advanced armies usually divide them into two groups: combat and combat support (combat support services).

The combat forces include air defense missile systems (ADMS--surface-to-air and ship-to-air), air defense artillery (ADA), fighter aircraft and also various ECM equipment.

Combat support forces include the electronic facilities designed to detect and report on the air threat and to provide radar support and control for air defense facilities and fighter aircraft.

Defensive measures against air attack include camouflage, dispersal of forces and rear-area assets, using terrain masking and engineer improvements, damage control measures, rapid, concealed movement of forces and measures to deceive the enemy about the true disposition of forces and assets. In a number of foreign armies, these measures are called passive air defense.

With the appearance of new weapons--missiles--there was a predominant opinion among certain NATO circles that aircraft had lost their importance and missiles would replace them. This also included fighter aircraft which would be replaced by air defense guided missiles as the only promising air defense weapon. But, further research, a comprehensive validation of new military propositions during numerous exercises and the experience of local warfare in Korea, Vietnam and the Middle East led to the recognition that a balanced development of missiles and aircraft was advisable. This concept is held by military circles in the developed capitalist countries.

A recent, urgent problem for air defense forces is low-altitude air defense. Low and very low altitude* surprise attacks against ground targets were

* In the opinion of NATO military specialists, very low altitudes range from several meters to 40m; low altitudes range from 40 to 300m; medium altitudes are 300-5,000m; and high altitude is above 5,000m.

practiced during World War II. However, this problem has become most critical with the appearance of ADMS and jet fighters and with the introduction of air defense radar facilities. At low altitude, radar detection range and target tracking range are limited by the earth's curvature. Foreign specialists assert that the time from target detection to engagement has been reduced so much that, in a number of cases, even supposedly extremely effective air defense weapons will not have time to fire on the target. In addition, current, long-range ADMS have a blind zone near the launch site where the guidance radars cannot guide the missiles. The low altitude air defense mission has recently been exacerbated by the widespread employment of helicopters on the battlefield, especially fire support helicopters.

According to the assessment of foreign military specialists, the October 1973 Middle East action showed that, in spite of significant progress in ECM systems, one of the primary methods for penetrating air defense systems was flying at low altitudes which guaranteed strike security and surprise.

The developed capitalist countries' armies have concluded that it is necessary to maximize the adaptability of current guided missiles for low-altitude air defense by modernizing and by developing new systems. Modernization is specifically proceeding in the area of improving timely detection of low-altitude targets by converting to CW; new weapons development is proceeding along the path of building special-purpose, short range, low altitude air defense missile and artillery systems. For the ADMS, they had to use various systems for timely detection, to sharply reduce the reaction time* and to significantly decrease the blind zone near the site. As far as tube ADA is concerned, they changed their views on its combat employment. Light ADA is now considered a rational supplement to ADMS for low-altitude air defense.

Foreign armies are equipped with self-propelled rapid fire ADA systems which are, as a rule, supported by early warning and guidance radars. When firing at short ranges, the disadvantage of the artillery shell's unguided trajectory is significantly reduced since the time of flight is very small, just seconds. At the same time, they do require high maneuverability for battlefield ADA systems and a reduction in their size.

The requirement to have diverse weapons in service with air defense is caused by the fact that offensive air weapons themselves are extremely diverse and their employment procedures and tactics against battlefield land forces and against rear-area assets also are diverse. As air defense defended assets, land force units and their rear areas are also not the same in tactical importance, composition, size or organizational structure, i.e., they are not the same in any of the indicators which determine the nature of their employment in various types of combat operations and in diverse environments. It is not feasible to consider employing long-range

* ADMS (ADA) reaction time is the time from target detection to missile launch (opening fire).

air defense weapons to fire against low-altitude aircraft and helicopters at close range. The battlefield air defense assets at the disposal of tactical commanders cannot be the same as the air defense assets employed by higher-level command personnel and designed to reinforce air defense in threat sectors. Different size and mobility requirements may be levied on air defense assets located in troop combat formations than on air defense assets operating in the defensive depth. The structure and weapons mix of foreign armies' AAD are based on the combined arms principle, i.e., AAD units and their command and control system are established in accordance with the combined arms units' formation. For example, a U.S. mechanized or armor division has a composite Chaparral-Vulcan air defensse battalion. It resolves issues on efficient resource utilization, supply, manning, training and other operational, tactical, organizational, and equipment issues and it also achieves greater economy in resource utilization.

The diversely structured air defense assets and complex equipment require a complete package of technical arrangements and the establishment of special maintenance units to guarantee reliable functioning and operational use.

Economic considerations are also important. Naturally, it is desirable to use expensive weapons economically. The cost of each air defense weapon must be recouped by the effect that it has in inflicting damage on offensive air weapons and in defending modern, well-equipped land forces against strikes. The British magazine RUSI has reported that, due to its ADMS with a range measured in several tens of kilometers, the British Army of the Rhein air defense can defend major theater forces and entire groups of point targets with air defense missile fire on a broad front and to a great depth. Moreover, by changing trajectories within a broad area, it is possible to concentrate or disperse the fire from a large number of air defense missile assets. In other words, an area defense is possible with a simultaneous defense of numerous point targets and units over a large area in contrast to direct (point) defense which is implemented by the limited-range weapons positioned directly at the defended asset (a small tactical unit). As a rule, a single area is covered by air defense assets with different operational ranges and different guidance and control methods; therefore, there is a composite defense, i.e., an area-point defense.

As reported in the press, the military leaders of the leading capitalist countries are no longer satisfied with the deployment of ADMS around isolated point targets but are defending entire major strategic sectors (areas).

A number of the NATO armies have special-purpose electronic warfare (EW) units. These units can be subordinate to an army or corps and they have various organizational structures, for example, a battalion organization (there are several companies in a battalion). These units are equipped with jamming assets for ground-based and airborne electronic equipment. These assets usually consist of special-purpose ground-based and airborne electronic jammers. In addition, these units are equipped with electronic intelligence (ELINT) equipment. The EW units are deployed in Army strategic formation's and large unit's operational areas and their mission is to jam in order to paralyze or hamper command and control of attacking enemy aircraft, impede or disrupt their radio-guided missiles and collect ELINT. Plans call for using EW assets to completely deny or reduce the effectiveness of enemy aircraft and missile operations and his radar-fuse missiles, to disrupt airborne radio communications equipment, navigation equipment, fire control equipment, IFF equipment and target designation equipment and to deceive the enemy on the true disposition of units and rear-area assets.

Thus, the availability of various air defense assets is an objective characteristic. Foreign military theoreticians acknowledge that the problem is to use all the various types of air defense forces with the greatest effectiveness and with very close coordination within the overall air defense system being developed for land forces.

Soviet military science has always been based on the fact that all military assets must be developed in an orderly combination and that success in armed conflict is achieved by the combined efforts of all the Armed Services and branch arms. This proposition completely applies to ADGT; ADGT tactics are inseparably linked to motorized rifle and tank unit tactics; with the evolution of the latter, the former is updated.

In the opinion of foreign military specialists, one of the principles of military development is that the operational employment of complex, diverse weapons systems, no matter how mechanized or automated they are, requires better trained personnel and a more complex organizational structure for military units and formations. The proper selection of an optimal organizational structure and establishment has a large impact on ADGT development as a whole. This structure must guarantee the required concentration of fire in the proper sectors, at the right time, with the most advantageous size of an engagement zone and with a maximum ratio of air defense assets to the defended area. Moreover, it must maintain uninterrupted defense during an operation and the capability of rapidly maneuvering air defense assets in a timely manner. At the same time, they believe that it is necessary to guarantee centralized control while retaining autonomy for lower-level units to execute coordination between air defense assets and fighter aircraft and with other air defense facilities.

The ADGT organizational structure and establishment must guarantee the combat formation's survivability and stability with the appropriate dispersal within the defended units disposition. In addition, the structure should take into account the requirement for rational organization for combat supply, maintenance and all types of materiel support and also for self-defense.

The basic U.S. ADGT administrative and tactical unit capable of waging independent combat operations is the battalion. The battalion consists of a headquarters, headquarters battery and four firing batteries. The Nike-Hercules air defense missile battalions are, as a rule, part of an ADA group and are used to defend the field army's most important assets. The composition of ADA groups and brigades within a U.S. army is not fixed but is set by the specific situation. ADA units are armed with surface-to-air guided missiles, guns and fire control systems.

Within the advanced capitalist countries' armies, there is a vividly pronounced trend toward including air defense assets in the tables of organization for combined arms formations, units, and even small units. The U.S. division has its own TO assets for low-altitude direct support--a composite, self-propelled air defense battalion (the Chaparral ADMS and the Vulcan self-propelled air defense gun) and they may be reinforced by a Hawk air defense missile battalion. In addition, the TO of each division's units includes the light, portable Redeye air defense missile; the FRG division TO has an air defense battalion equipped with 40-mm twin-barrel, self-propelled air defense guns which are being replaced by the Gepard 35-mm twin-barrel, self-propelled air defense guns; the British division's TO contains a light ADA regiment with 40-mm guns and the Rapier missile.

Foreign military specialists believe that the organic division air defense assets should be supplemented with assets held by higher headquarters.

According to the views of NATO specialists, the Hawk and Nike-Hercules missiles, which are field army assets and sometimes army corps assets, reinforce division air defense by defending certain areas in coordination with fighter interceptors.

Due to the concern of the CPSU and the Soviet Government, our ADGT is continually being updated and its reliability and effectiveness are increasing.

Widespread research and organizational measures have resulted in the widespread introduction of air surveillance radars and the development of effective air defense guided missiles.

The superior fighting efficiency of our weapons systems was demonstrated in combat with modern aircraft in Vietnam and the Middle East. However, with the continual upgrading of the air threat and its weapon systems, the importance of the air battle is continually increasing and it demands a search for more up-to-date, new methods and procedures to counter the air threat.

The evolution of air defense as an independent branch of the Army was due to the large role played by prominent Soviet military commanders: MSU D.F. Ustinov and R. Ya. Malinovskiy; Gen of the Army I.G. Pavlovskiy; Arty Mar V. I. Kazakov, Arty Col Gen V.G. Privalov and P. G. Levchenko; and Arty Mar P. N. Kuleshov.

Chapter Three

Air Defense Organization

7. Air Defense Command and Control

The fundamental changes in the means and methods for combat operations--changes which were brought about by progress in military technology--have brought enhanced force command and control to the fore as a major problem area.

National defense interest urgently require that commanders and all officers master force command and control methods to a tee, have a feel for the new, see the long-range prospects for military development and be able to find effective ways to resolve problems which arise.

Military science in general and force command and control in particular are closely linked to social, economic and ideological factors. A scientific approach to force command and control presupposes that these factors will be considered and that not just the achievements of military science but also the achievements of systems being controlled are dynamic; they are evolving and improving as social conditions change and as there are changes in technological progress. Command and control is the continual exercise of authority by commanders and headquarters over subordinate forces to accomplish concrete missions and achieve definite results.

Air defense command and control consists of thorough, skillful organization, all-round support for air defense unit combat operations and a mission-oriented direction of their efforts to successfully accomplish their assigned missions in defending units and other assets against enemy air strikes.

The general objectives of air defense command and control are:

maintaining constant combat readiness and an alert organization;
uninterrupted collection, study, analysis and assessment of situation data (especially forecasting probable combat operations by

the enemy air threat) and preparing the estimates and recommendations required for decision making;

timely planning of combat operations and disseminating operational missions to air defense units, guaranteeing the organization of coordination with defended forces, fighter aviation and National Air Defense Forces and maintaining this coordination during combat operations;

organizing all-round support for combat operations by air defense assets;

organizing and maintaining reliable communications with subordinates and cooperating air defense assets, adjacent units and higher headquarters and also exercising force command control;

organizing the deployment, arrangement and combat operations of command and control centers and organizing their relocation, security and defense;

continually following up on the performance of assigned missions;

submitting reports to higher headquarters in a timely manner and systematically reporting to subordinates, cooperating headquarters and adjacent units on the situation;

accounting for personnel and materiel;

studying and disseminating to air defense units the consolidated combat experience and also continually improving command and control methods.

The foundation of command and control is the commander's decision.

Air defense command and control at all echelons must be efficient, firm, uninterrupted, stable, flexible and secure.

Thus, air defense command and control is a complex, continuing process which can arbitrarily be divided into two parts.

The first part includes arrangements for planning and all-round support for combat operations by air defense assets; the second part includes direct command and control of air defense assets while repelling enemy air raids.

Although there are a number of features typical of air defense assets, the former measures are primarily based on common air defense of ground troops command and control principles.

The latter measures are fundamentally specific in nature and are especially critical since the air battle takes place in three dimensions. The air threat and air defense assets (missiles, fighters) move in complex trajectories. The location of engaged forces is extremely fluid, it is fixed for a short period of time, it is not tied to firm landmarks and it is like arbitrary points in a space with variable coordinates. There are constant and swift changes not only in the opposing weapons systems' course, altitude and speed but also in the location of the battle area; and, it is extremely difficult to determine the pattern of these changes.

Due to the extremely high, dynamic nature of airborne events, data transmission speed becomes especially important because data dissemination is required on a real-time basis.

It is necessary to take into account the fact that the very nature of the command and control process makes a certain data lag unavoidable; and this means there is a decision lag since each decision is made from an analysis of data on a situation which occurred in the past while the decision will be implemented in an environment which unfolds in the future.

The commander makes his forecast by making a hypothesis on the future course of events; the maximum value for the data lag is limited to the time that changes having a significant effect on the decision may occur in the situation. During the preparations for combat operations, some lag is permissible to a certain extent since the forecast-based decision on the organization of air defense can make provisions for this through alternative combat actions and by earmarking reserves. When an attack is being repelled, receiving delayed data on a probable target is equivalent to letting the target through. Simplifying, it is possible to state that time is measured in hours (or possibly even in days) during the first period while it is measured in minutes or even seconds during the second period. Therefore, there is a very critical issue of resolving the time budget problem both when assigning missions to air defense assets and when implementing coordination with fighter aviation, especially during low-altitude air defense and in an ECM environment.

The time budget is primarily dependent upon the range for detecting the air threat, the organization of intelligence, air situation data collection, processing and analysis speed and the timely dissemination of missions to firing assets, i.e., it is dependent upon the level of command and control automation.

In their pure form, these two periods of air defense command and control may not always be separated in time, since, as arrangements are being made to improve air defense, enemy air raids may occur at the same time and they must be repelled. However, functionally, the two periods are very different and, methodologically, it is advisable to consider them separately, especially when determining the requirement for and degree of command and control automation. It is clear that the greatest requirement for automation is in those processes which require real-time data. Command and control automation should primarily eliminate or reduce the existing trade-offs between insufficient data on the air threat and the requirement to predict its actions, between the difficulty in evaluating the situation and the requirement to make quick decisions and between command and control centralization and decentralization. Command and control automation is one of the conditions for resolving the problem of gaining time and of enhancing command and control performance and air defense effectiveness as a whole.

Command and control effectiveness is the ability to carry out its assigned functions within the extablished period of time, with a minimal expenditure of resources and with top-notch performance.

It is well known that the time for command and control (T_c2) is represented by the equation:

$$T_c2 = T_c + T_D + T_T$$

where T_c is the data collection and processing time;
T_D is the situation clarification and decision making time;
T_T is the time for formulating and transmitting command data to executive agents.

Command and control efficiency is the degree to which the command and control system fits force capabilities and the situation. In its most general and simplest form, efficiency is defined as the difference between the maximum time for command and control measures (T_c2^{max}) and the actual time expended (T_c2^a). If the term $T_c2^a \leq T_c2^{max}$ is met, command and control is efficient enough.

In turn, the maximum time is defined by the difference between the critical time (T_{cr}) and the time spent on executive agents' actions (T_{act}). The critical time is the time that, if exceeded by the actions of the entire command and control system and the forces (i.e., the executive agents) on the decision,* the decision will not have the required effect. Therefore, it must meet the condition:

$$T_c2 = T_{cr} - T_{act}$$

The time available to air defense to counter the enemy (i.e., essentially, T_{cr}) is defined by the approach time:

$$T_{app} = \frac{D}{V_T}$$

*It is assumed the decision is correct for the situation.

where D is the distance from target detection (receipt of initial data on it) to the strike objective exposure line;
V_T is the target speed.

The sooner air defense begins to act on the target, the more effective it will be.

From the above, it follows that a hierarchical command and control system must have:

$$T_{C2} = T_{cr} - T_{act}.$$

Based on this equation, it is obvious that efficiency can be increased two ways: a) by reducing the number of command and control levels (N); b) by decreasing the time for command and control measures (min T), i.e.:

$$\min \begin{cases} \sum\limits_{\tau=1}^{\min N} T_{C2}, \text{ a;} \\ \sum\limits_{\tau=1}^{N} \min T, \text{ b.} \end{cases}$$

Each second of time saved is achieved by putting a large work load on command and control elements or by introducing expensive computer equipment. The possibilities for reducing the number of command and control levels are determined by a number of factors, specifically, by the organizational structure and establishment of the defended forces which the particular air defense organization is part of. The possibilities for decreasing the time for command and control measures are also limited. Consequently, command and control efficiency must be increased within intelligent limits, i.e., it must have the optimal value determined by tactical, technical and economic feasibility. It is advisable to optimize both ways of enhancing command and control efficiency. In this respect, a large role should be played by automation and by using various mathematical methods.

Air Defense Command and Control Automation

From a cybernetic point of view, air defense is a complex, integrated structure with numerous, interlaced flows of data, material and energy, flows which require coordination and regulation with a speed and accuracy which are frequently beyond human capabilities. Command and control is the process of interfacing command and control elements and assets; during this process, the data which is characteristic of it is circulated and processed.

The modern environment requires an all-round increase in command and control efficiency, effectiveness and reliability; this requires automation which implies an integrated employment of the appropriate scientific methods and automatic equipment. The significance of automation consists of transferring labor intensive command and control operations to electronic computers and other equipment while retaining a leading role for human creative, intellectual activity.

Automation is preceded and accompanied by mechanization of command and control; this mechanization consists of using auxiliary equipment to accomplish mechanical (manual) operations in order to cut down on the time spent by commanders and headquarters on non-creative work.

We can distinguish the following types of command and control systems: automatic, automated, manual.

Automatic command and control systems provide for minimal human participation.

As a specific feature of an operational command and control system, decision-making is an especially creative process. The primary function of command and control--making the final decision--is still a human function--the commander's function. Therefore, no command and control system can be completely automatic. It should be automated to the maximum extent. Soviet military science debunked and repudiated the bourgeois concepts of "the electronic commander" and "push-button warfare."

Only the commander is able to uncover all the fine points and details in the operational situation and find reliable ways to beat the enemy. Even with the highest degree of automation, the commander is still the central figure and the headquarters is the primary command and control element. The commander makes the decisions and the headquarters plans combat operations. The equipment only facilitates the performance of the commander and staff officers in command and control. Even during the prewar years, it was obvious in ADA, for example, that air defense gun modernization provided a slight increase in effectiveness while aimed fire against high performance targets was simply impossible without fire control automation. In the 30's, we began to use mechanical calculators--the AAD [anti-aircraft director]; but, they were only used for line of sight targets. The appearance of fire control radars made it possible to fire ADA in any weather, day or night. During World War II, we developed electro-mechanical and electrical ADGT's and automated air defense battery target track and gun slewing functions. The introduction of radars improved the air warning service and GCI. But, air defense command and control was still based on a plot-board system, i.e., manual operations.

The operational work of air defense command posts remained almost completely manual right up to the end of WW II. At some command posts, they used air situation scopes which consisted of a map of the area pasted to the scope's glass. On the glass, with the map as a background, they manually plotted enemy aircraft and air defense fighter flight routes. These scopes made it possible for the command element to see the air situation picture in a certain area and they facilitated control of air defense assets. At the state-of-the-art in aircraft speed at that time, these scopes were a step forward although they did not completely resolve the problem.

After the war, air defense command and control began to be based more and more on technology. The command element had a capability to display the total air situation on plot boards. However, the technical equipment was inadequate.

Along with this, technical equipment, especially electronics, began to be widely designed into ADA, ADM and fighter aircraft systems as an integral part of them. Because of this, there was an increasingly negative effect from the lack of fit between the plot-board command and control methods (which provided primarily manual operations with a large lag time) and the electronic target acquisition and tracking systems. The command and control system's operating speed began to play a major role in supporting data collection and processing accuracy and reliability. With the employment of more modern air defense weapons and hardware and with their complex methods of employment, there was greater support for the idea that human capabilities to rationally employ air defense forces in a complex combat environment were very limited. There was a significant increase in the importance of the time factor. All the developed countries' armies were intensively searching for various technical solutions to the problem of achieving a high operating speed for the entire command and control system, from top to bottom. As a result, this problem was solved by electronics, one of the effects of the progress in technology on military affairs. It was feasible to use computers and the most up-to-date high-speed communications equipment integrated with various data displays to assist man. It was possible to develop electronic air defense command and control systems.

The first electronic digital computer built in the U.S. soon after WW II had a speed of 5,000 additions or subtractions per second. During the past 20 years, there has been three generations of computers. The first generation of vacuum-tube computers was followed by the second generation of tranistor computers and the third generation of integrated-circuit computers. Computer speeds have increased to several million operations per second. The next generation of large, integrated-circuit computers will have an operating speed of tens of millions of operations per second. Finally, the fifth generation of computers based on completely new principles, whose appearance can be anticipated in 1979, in the opinion of foreign specialists, will have a speed of billions of operations per second.

In recent years, there has been an increased trend toward developing and introducing small machines which, as foreign specialists believe, are absolutely necessary for electronic command and control systems, especially as peripherals integrated with powerful computers. To operate in a field environment, they believe, special requirements should be levied on computers, primarily regarding mobility, size and weight and also the ability to operate under different, adverse weather conditions. These computers must be able to be turned on and brought on-line in several minutes. The machines themselves should be mounted in transportable vans.

The greatest pressure on personnel operations and speed is the requirement for labor intensive command and control measures while repelling enemy air raids.

In the opinion of foreign specialists, the following air defense command and control processes should be automated: air situation data pick-off and transmission at radar sites; the reception and processing of radar data from various sources; data display on appropriate scopes, air situation displays and dynamic battle displays; air defense force alert status data collection, synthesis and display; the development of initial decision making data to repel an enemy air raid; the assignment of missions to executive agents; target assignment and weapons guidance.

The automation of all these processes must be integrated in such a manner that each process flows into the other without creating any difficulties, i.e., integrated automation is required.

An integrated electronic command and control system is the totality of equipment and personnel brought together in integrated command and control nodes which guarantee the necessary pace and coverage of command and control based on a coordinated automation of command and control processes in accordance with friendly force organizational structure and its command and control system.

The foreign integrated electronic command and control system includes: data extraction systems (sensors); communications channels to transmit data from sensors to processing centers; command and control center data processing and control calculation--commands--equipment; communications channels to transmit commands to controlled assets and data on their status to command and control centers; and subordinate unit command and control centers. Moreover, all elements of the air defense of ground troops electronic command and control system must be sufficiently maneuverable.

Based on current foreign systems and those under development, a general view of electronic command and control system operations is presented below.

A functional electronic command and control system first requires sensors which are primarily radar sites. The radar data is subjected to primary processing--it is changed to a form suitable for computer input.

The objectives of primary data processing are: extracting the useful reflected signal from the receiver's output signal which is a mixture of signal and noise; determining target coordinates from the reflected signal; identifying the reflected signal (IFF) and determining raid size (multiple or individual).

The computer conducts secondary processing of the radar data; this process defines target tracks and tracks detected targets. During tracking, the blips received are continually matched to the tracks, the coordinates are smoothed, target parameters and other amplifying data are computed and numerical designators are assigned. The processed data is digitized and a report is sent out on the communications channel to a preset addressee (an air defense command and control center). This center collects data on the enemy from intelligence assets and from its own operational assets. All of this data is synthesized, i.e., it undergoes terciary processing which: decodes the report, puts the target coordinates and amplifying data into a common coordinate system and common time, matches the radar returns from different sites to a single target track, computes synthetic target coordinates and amplification data and prepares a target report to transfer to a display or to be put into the computer memory.

So that the computer will recognize and discard improbable data, programs are compiled ahead of time which make provisions for situations of doubtful validity and which require that steps be taken to enhance data reliability or discard it.

The computer is also used to disseminate the operational and tactical data received and processed to various display sets (displays, scopes) depending on its importance and scope and to make coded notations (symbology) and explanatory legends (amplification) for the data.

Then, the air defense command and control center team prepares data for the commander to make his air defense force employment decision. The content of the decision depends upon the specific situation and the level (echelon) of command and control.

In general, foreign specialists believe that the nature of the decision depends upon the location of the command and control center within the hierarchical structure of the electronic command and control system and it can be boiled down to either distributing air defense efforts in sectors, particular areas of the air space, where multiple targets are located or assigning targets by indicating specific targets or target formations. The latter is predominant at the lower command and control echelons. In any case, there is an optimal assignment of active air defense assets to targets located in the controlled air space. Moreover, a particular operational method may be prescribed. The level of detail in the decision also depends upon the command and control method adopted: with centralized control, the decision is more detailed; commands flow down the chain of command and reports flow up; with decentralized control, the lower-level commanders make the decisions on their own and report to higher headquarters based on preliminary, general instructions; with mixed command and control, both methods are combined.

The foreign press has reported that a characteristic feature of air defense command and control for low-altitude air defense during the wars in the Middle East and Vietnam was widespread decentralization, especially at the tactical level. The dynamic nature of the situation and the time factor made it necessary to concentrate command and control of active air defense assets in the hands of unit commanders and, in a number of cases, in the hands of small unit commanders and independent crew commanders. It is anticipated that, when timely warning is not provided for active air defense assets, autonomous operations will be required not only for fighter interceptor formations and crews but also for individual ADM and ADA units.

The computer can calculate various alternatives and display the result of its calculations so the commander can analyze them and select the optimum alternative. Printers can be used to display the data and alternatives on paper in a readable form.

In accordance with the decision, the computer (in the SAGE system) transmits command reference data to executive agents by digitizing the text of the decision, issuing a command to the transmission link and signaling transmission of the command. The computer can also exercise direct control over air defense missiles, fighter interceptors and radar sites if this is part of the command and control center's functions.

One of the major components of an electronic command and control system is the data acquisition and transmission equipment. Data can be filed by recording it on a storage medium for long-term storage or reproduction as necessary. It is also possible to make special-purpose peripherals to reproduce data in document form or graphics.

The less time air defense has at its disposal, the greater the independence required by lower echelons. For example, as reported in the foreign press, a NATO Air Defense Region will transition from centralized command and control (at the Region Operations Center) to decentralized command and control (at the Sector Operations Center) when there is intense ECM or when countering low-altitude targets, i.e., when there is a reduction in detection range and time available.

Air defense command and control is dependent upon target detection capabilities. The detection range requirement (R_r^{det}) can be expressed in a general form by the following equation:

$$R_r^{det} = V_t \ (T_c2 + T_{act}) + D \pm Z,$$

where D is the distance from the location of active weapons to the target engagement position;
Z is the radar site offset relative to the location of active weapons.

From this, it follows:

$$T_c2 = \frac{R_r^{det} - D \pm Z}{V_t} - T_{act};$$

$$T_{max} = \frac{R_r^{det} - D \pm Z}{V_t} - T_{act};$$

where T_c2 can, for a given case, be viewed as the maximum time to be spent on command and control measures;
T_{act} is the time for executive agent actions.

As detection range increases, there is an increase in T_{max} and, this means, the air defense command and control center will have more time to carry out its function. By the same token, a reduction in the time for air defense command and control center operations, as well as an increase in R_r^{det} will facilitate earlier commitment of active weapons. In other words, it is necessary to strive for a situation where T_{max} is smaller than T_{avail}. Then, it can be anticipated that there will be a time budget which can be used if necessary. The requirement for using this budget can arise unexpectedly, for example, when weapons which have already been assigned a mission are put out of commission by an enemy strike. The foreign press has emphasized on numerous occasions that air threat warning time is extremely limited, especially in the area adjacent to the line of contact. For example, in the Central European Theater, with its relatively small depth, the FRG border areas, which are the outposts in the NATO system, will only have a few minutes of warning time.

Modern Air Defense of Ground Troops Electronic C^2 Systems

At the present time, foreign armed forces are equipped with various types of automated equipment, including equipment designed for Air Defense of Ground Troops fire control and command and control.

Regarding electronic fire control systems, it is well known that they are used on a widespread basis in air defense and air systems where they are integral components of the particular system.

As far as electronic command and control systems are concerned, at present, there is a more pronounced trend toward supplying organic air defense assets with mobile systems at the operational and tactical command and control echelons. Moreover, let's point out that, at the tactical echelon, it is considered adviseable to have systems which are able to operate autonomously during low-altitude air defense.

The aggressive NATO bloc has developed the NADGE electronic air defense command and control system. This is a fixed system which covers the area from Norway to Turkey; it consists of a developed network of multi-role, hardened and prepared air defense command and control centers and radar sites. It is supplemented by mobile systems in accordance with the role and location of a particular bloc nation's air defense forces within the overall NATO air defense structure and in accordance with operational wartime employment plans. A major purpose of automation is to gain the time required to improve effectiveness against high-performance offensive air systems. The time expended within the NADGE system on target detection, identification, data transmission and decision-making to employ a particular air defense asset against the target is sufficient to intercept targets flying at Mach 2.

As an example of a mobile system designed for field ADGT missile system command and control, we can cite the AN/MSQ-4 Missile Monitor electronic command and control system which makes it possible to: detect, identify and track targets; determine three-dimensional co-ordinates (azimith, range, altitude); process, synthesize and store target data; display the air situation; allocate targets to air defense missile battalions and batteries; and automatically transmit data in both directions from the army air defense CP to battalion and battery CP's.

Just one of the systems is designed to control several Hawk or Nike-Hercules missile battalions. If command and control from the field army air defense CP is disrupted, the batteries can be controlled from the battalion CP's using the AN/MSQ-18 equipment. In addition, it is anticipated that a battery--with its target acquisition and tracking radars, missile tracking radar and computer--will be able to fire autonomously.

The electronic command and control systems continue to be upgraded. They have developed a new Missile Mentor system with solid state electronics; it takes up significantly less room and requires four times fewer support personnel. This system makes it possible to search for targets, track them, evaluate the air situation, monitor battery alert status and obtain data on friendly losses.

To transmit the air situation data required for fire control of Redeye missile sections and the Chaparral missile batteries and Vulcan gun batteries of the divisions's composite battalions and to transmit data on enemy aircraft flying at medium altitudes to Hawk and Nike-Hercules batteries, the U.S. Army has developed the FAAR system--electronic forward area alerting radar system.

All system components--the target detection radar, the IFF equipment, communications equipment and power supply--are mounted on a 2.5-ton wheeled vehicle with high cross-country performance. At the composite air defense battalion's firing batteries and at Redeye missile crew firing positions, they have portable display equipment (weighing 5.8 kg) which receives FAAR CP data indicating air space sectors where targets have been detected. Guided by this data, the batteries (teams) will open fire.

Targets are displayed as colored dots (green for friendly aircraft and red for enemy aircraft). The displays are equipped with an audio alarm system which is tripped when data is received on a new target.

It has been reported that the FAAR radar operates in the VHF band (from 390 to 1550 MHz). For crew protection, the set can be controlled from a console remoted 45 m away.

The job of upgrading Air Defense of Ground Troops electronic command and control systems continues abroad.

Using Mathematical Methods To Accomplish Air Defense of Ground Troops Missions.

For a quantitative evaluation of military situations, two types of mathematical methods can be used:

simple analytical methods based on averages and basic relationships (in the form of equations, calculation charts and tables);

methods producing various labor-intensive estimates based on statistical data or a probability approach to the analysis of combat operations.

Simple analytical methods. Simple analytical methods are used to make the various operational estimates, primarily preliminary in nature, required to organize and plan for air defense. For example, approximating the effectiveness of the air defense group being created, estimating the probable force ratio for repelling enemy air attacks, making a rough estimate of air defense forces required to establish a group with the required effectiveness and calculating a rough estimate of the munitions required.

The effectiveness of an air defense group means the ability of its forces to destroy the air threat in order to deny the enemy aerial reconnaissance and to provide the required assurance that his strikes against defended forces and rear-area assets will be prevented.

The rough estimates of an air defense group's effectiveness are described below. Based on the number of air defense assets and their operational characteristics (altitude, range, operational speed) and considering the probable duration of enemy air strikes, the potential (maximum) effectiveness is determined. It is expressed by the expected number of enemy aircraft which will be downed by active weapons--air defense weapons and fighter aircraft; then, these results are added together. This method also makes it possible to approximate the force ratio for repelling attacks.

Let's take a general, theoretical look at a possible sequence for making these kinds of calculations.

Active weapons are broken down into components (air defense weapons and fighter aircraft); then, they are broken down by type. All types of air defense weapons may be part of the air defense group. Consequently, at first, it is necessary to calculate the effectiveness of individual systems.

A firing unit usually means the smallest unit (under the existing organizational structure) which is able to carry out a firing mission. This concept is arbitrary and it is introduced for convenience in making the operational and tactical calculations. The expected number of enemy aircraft which will be destroyed by a specific type of air defense system can be calculated from the following equation:

$$E^{sys}_{dest} = n_{fu} \cdot \ddot{n}_r \cdot P_k \cdot R_p \cdot F_{c^2}$$

where n_{fu} is the number of fire units which equals the specific number of channels;

n_r is the number of rounds fired by each firing unit;

P_k is the target kill probability for a single firing unit;

R_p is the ratio of air defense assets taking part in repelling the attack;

F_{c^2} is the command and control factor.

In turn, these formulas are calculated from a number of functions.

The number of rounds fired by each firing unit can be calculated two ways:

1) based on the stock of missiles (S) located at a single firing unit's launcher and the missiles expended during a single launch (γ);

$$n_r = \frac{S}{\gamma} .$$

for ADA, S is the unit of fire;

2) based on the length of the firing cycle (t_c) and the duration of the attack (T_a):

$$n_r = \frac{T_a}{t_c} ;$$

or, together:

$$n_r = \min \frac{s}{\gamma} ; \frac{T_a}{t_c} .$$

A single firing unit's target kill probability (P_k) is calculated ahead of time according to the formula:

$$P_k = 1 - (1 - P_1) \gamma ,$$

where P_1 is the target kill probability for a single missile from a specific type of system or for a single round from an ADA firing unit; γ is the number of missiles launched at the target.

Since P_1 is usually taken from a table, it is necessary to insert a factor (F_{cm}) which takes into account all types of enemy aircraft air defense countermeasures. Then, the formula will be:

$$P_k = 1 - (1 - P_1 \cdot F_{cm}) \gamma .$$

The participation ratio shows the percentage of a specific type of system's firing units which can be used to repel an attack in a specific area (sector) and at a specific altitude.

In general, R_p is calculated using the following function:

$$R_p = R_c \ (1 - R_m) \cdot R_z$$

where R_c is the combat readiness ratio which measures the percentage of total listed strength firing units whose equipment and personnel status permits them to participate in repelling the attack;

Rm is the movement ratio which expresses the percentage of air defense assets which cannot participate in repelling the attack since they are enroute, changing sites or setting up in firing position at new sites (this ratio can be taken from exercise experience or combat experience);

R_z is the ratio which measures the percentage of targets in the attack which will be within a specific air defense system's lethal (firing) envelope; when this envelope is large enough, i.e., when it exceeds the size of the air space for probable enemy offensive air operations, or is equal to it, $R_z = 1$.

An acceptable accuracy for this kind of approximation can be obtained by using average values for R_p, values which are calculated in advance for various types of combat operations based on experimental data.

The command and control factor (F_c2) is inserted because the maximum effectiveness is calculated based on an assumption of being able to exercise ideal command and control; but, for practical purposes, it is necessary to consider the possibility of command and control disruptions; F_c2 is calculated based on practical experience considering the special features of current intelligence and warning assets, the degree of automation in the command and control system and the levels in this system.

The total effectiveness of the entire air defense group is expressed by the totals of the expected numbers of enemy aircraft which will be downed by each type of air defense system:

$$E^{adg}_{dest} = \sum_{i=1}^{n} E^{sys}_{dest} \; i \, .$$

The ratio between the expected number of aircraft destroyed and the number of aircraft participating in the attack ($\mathcal{M}$) can be taken as the ratio of relative effectiveness for the air defense group being established and also as the force ratio index:

$$\mathcal{M} = \frac{E^{adg}_{dest}}{N} ,$$

where N is the number of aircraft taking part in the attack.

For example, according to the enemy threat assessment, it is anticipated that the attack will consist of 200 aircraft. The expected number of aircraft which will be destroyed by the air defense group is 120, $\mathcal{M} = 120 \div 200 = 0.6$. It is easy to conclude that this index provides an idea of the force ratio required to repel an attack. For this purpose, it is necessary to relate this index to the effectiveness ratio which is required to confidently discuss the possibility of disrupting the enemy attack. The required ratio of relative effectiveness can be found in practical experience from exercises and combat operations. It is logical to assume that the attack can be considered disrupted if the air threat is destroyed (at a maximum) or aborts the attack (at a minimum). Based on the experience of the Great Patriotic War and WW II, enemy aircraft losses of 15-30 percent led to aborting the attack. Under contemporary conditions, the required percentage of losses will be different depending on the nature of the attack, enemy strength, air defense weapons used, the nature of defended force operations, the degree of defended force concealment and other factors which will have an effect on friendly force combat readiness and enemy land and air force combat readiness.

For a general case, let's designate R_{rel} as the ratio of relative air defense effectiveness where the enemy will suffer such losses that he will abort the attack. This ratio will also express the ratio for required relative effectiveness, i.e.:

$$R_{AD}^{req} = R_{rel}.$$

It is easy to conclude that sufficient relative effectiveness for the air defense group being established must meet the conditon:

$$R_{AD}^{rel} = R_{rel}.$$

But, at this point, it is necessary to consider the fact that the air defense force group does not remain constant (it suffers losses). Therefore, it is necessary to take into account the air defense force loss ratio (R_1) which expresses the relationship between the number of air defense assets put out of commission by enemy strikes and the total number of air defense assets.

R_1 is calculated for a specific situation considering the experience of combat operations or experience from tactical and operational force training.

Considering the loss ratio, the required relative effectiveness ratio must meet the condition:

$$R_{AD}^{req} \geq \frac{R_{rel}}{1-R_1} \quad .$$

Using more refined mathematical methods. During recent years, military practice has seen widespread use of more refined mathematical methods, such as, queueing theory, game theory, mathematical programming, etc.

Each of these theories has its own characteristic features from the point of view of the processes described and the specific missions accomplished. Let's take a brief look at some of them.

For a mathematical description of certain military missions whose accomplishment depends upon a large number of random factors, queueing theory methods can be used. For example, the air defense force mission of repelling an attack by enemy aircraft is a typical queueing task. In this case, the ADA or ADM group represents a queueing system. Each site within the system performs the role of a servicing channel whose task is to fire on enemy aircraft (service requests) which are received by the system at random points in time. The firing at aircraft continues for a certain random period of time, after which the air defense system is free and ready to receive a target allocation and fire on the next target.

When repelling an attack by a large number of aircraft, part of the targets may not be fired on (serviced). Thus, depending on the number of air defense systems and their productivity as well as the nature and density of the enemy aircraft attack, the air defense group will have a certain throughput capacity which makes it possible for the system to carry out its mission more or less successfully.

The object of queueing theory is to establish a relationship between the nature of the flow of requests, the number of channels, channel productivity, the operating rules of the queueing and service results (effectiveness).

Depending on the task environment, various measures of service effectiveness can be used; for example: the average number of requests which the system can service per unit of time; the average number of requests being rejected and leaving the system without being serviced; the probability that a request will be accepted for servicing; the average waiting time for servicing; the average number of busy channels; the average number of requests in a queue, etc.

In military practice, queueing theory is used to accomplish tasks on organizing air defense force command and control to repel enemy aircraft attacks by analyzing equipment reliability, simulating combat operations, etc.

In general, there are two types of queueing systems:

1) rejecting systems; a request arriving in these systems when all channels are busy is rejected and leaves the system without being serviced;

2) holding (queueing) system; a request received by these systems when all channels are busy enters the queue and is held until one of the channels is free.

When solving a number of practical problems, it is necessary to analyze situations where there is a conflict of interest between two or more sides which are pursuing different goals. Such situations are called conflicts.

The requirement to analyze these situations led to the appearance of special mathematical methods--game theory and statistical decision theory.

The goal of game theory is to develop recommmendations for a rational (optimal) model of actions for the parties to a conflict. To analyze a particular conflict using game theory, it is necessary to have the appropriate input data. These data are obtained from an evaluation of the effectiveness of all the possible combinations of one side's operational methods and the other side's operational methods.

When conducting a mathematical analysis of these situation, it is necessary to design a simplified, rough model. This model is customarily called a game. The game plan is called a strategy by convention. Solving the game means finding the optimal strategies for both sides and determining the value of the game.

An extremely efficient method of studying the effectiveness of combat operations as well as various aspects of command and control is simulation. In general, simulation is a method of studying a particular real-world phenomenon using special models which make it possible to depict the basic features of the phenomenon being studied.

There are two basic methods of simulation: physical and mathematical.

Physical models are similar to the original in physical make-up and appearance; but, they differ from the original in size, speed and other properties being considered. Physical models are used widely in the practical activities of air defense forces. Actually, all exercises and command post games are physical models of combat operations.

The shortcomings of physical simulation are: unwieldiness, difficulty in studying a large number of alternatives and high cost.

The majority of problems are solved using mathematical models. Mathematical simulation consists of taking the information problems or tactical problems being studied and, consequently, the command and control processes related to them, and formulating them in the language of mathematics and formal logic.

A mathematical model using the tools indicated above establishes the relationship between the criteria for effectiveness or, as it sometimes called, the target function, and the factors being considered for a solution to a particular problem. Based on the method of accomplishing them, mathematical models can be divided into analytical and statistical models.

In the analytical model, all the quantitative factors are related to analytical functions with various types of equations. This system of equations which makes it possible to calculate a value for the criteria is the analytical model.

An example of this kind of model is Ehrlang's Model which is used to study the throughput capability of various queueing systems. Another example of an analytical model is the mean dynamic equation which is used to simulate force combat operations.*

Statistical simulation is based on the so-called Monte Carlo method. The essence of the method is that, instead of calculating criteria for the effectiveness of specific types of combat activities based on complex analytical functions, they are determined through sampling. The method is based on the limit theorems of probability theory; according to these theorems, as the number of independent trials increases, the frequency of the events will approach their probability while the arithmetic averages of the random values obtained from observation will approach the mathematical expectations.

Force combat operations are affected by a large number of diverse, random factors (detection or non-detection of an enemy aircraft, timely or untimely accomplishment of a command and control task, etc.). Therefore, the outcome of both the entire process and its basic components will be random and can be determined by tosses of a coin.

The basic method consists of simulating individual runs of the random process to obtain the necessary statistical data. To accomplish this, various methods are used to generate random numbers from 0 to 1. By comparing the random numbers to the probabilities for each run, it is determined whether the event has occurred. If the random number selected is smaller than the desired probability, the event has occurred; if it is larger, the event has not occurred.

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* The models based on mean dynamic equations make it possible to forecast the battle between two belligerents with various types of methods considering losses, command, control and intelligence.

The distribution of random event probabilities is derived from exercise experience and range tests. After running a number of trials of the process being studied, the results are analyzed statistically. Thus, the method of statistical trials is based on the most general theorems of probability theory and are unlimited. This method can be used to solve any problem and, with a sufficiently large number of runs, it can provide any degree of accuracy.

The advantages of this method have caused it to be used on a widespread basis to solve the most diverse, complex combat simulation problems. But, it has a significant shortcoming--it is very labor intensive and requires a high-speed computer with a large memory.

The strict requirements for efficient command and control leave too little time for calculations. This makes it difficult to use statistical simulation in the army.

Preference is given to those types of mathematical models which have maximum simplicity and can be run on the computers available at air defense of ground troops command and control centers within the maximum time available. These requirements are primarily met by analytical models. They are easier to do manually and require significantly less time for the calculations.

As pointed out previously, the missions accomplished by air defense of ground troops command and control elements are divided into 2 groups.

The first group includes missions accomplished for force planning and organization and all kinds of support. These missions are being continually accomplished regardless of the combat environment. The time alloted to their accomplishment can be several minutes or several hours.

The second group includes air defense combat operations command and control missions while repelling the enemy air threat. This group of missions must be accomplished on a real time basis.

Automation is based on electronic computers.

The accomplishment of a particular mission using a computer is only possible when the tactical or theater-level mission being accomplished has been translated into machine language.

The translation of the mission into machine language primarily means that it must be formalized, i.e., presented as instructions (mathematical and logical operations--an algorithm) which, when formally carried out, can solve the problem.

Overall, to solve a particular problem on a computer, it is necessary to develop so-called software which is the totality of tactical and strategic mission descriptions, algorithms, programs and instructions which make it possible tc use automated equipment and computers for force command and control.

From the point of view of computer processing, software is conventionally divided into internal and external packages.

Internal software is the package of programs which facilitates computer operations or other computer equipment operations and which guarantees an effective organization of the computer process within each command and control center in the electronic command and control system.

External software is the package of programs which guarantees that the entire electronic command and control system will function as a total command and control center system. Of greatest interest to military specialists is the process of developing the external mathematical description. It includes problem formulation and the strategic-tactical mission description, drawing up algorithms and programming.

Problem formulation means a brief presentation--without any extraneous details but sufficiently accurate presentation--of the input for the problem solution and what should be obtained as a result of the solution. Moreover, conditions for the solution are usually set forth.

For example, a problem formulation could be set to allocate ADM fire against targets to guarantee the largest expectation for damaging the air threat.

The strategic-tactical mission description is the most important stage in developing external software. It is during this stage that mathematics and military science are actually united. The strategic-tactical mission description contains:

a clear-cut definition--as close to a mathematical definition as possible--of the commander's goals in accomplishing his mission;

a list of the input required to accomplish the mission;

selection of criteria of effectiveness;

recommended methods of accomplishing the mission;

the type of output required for interim and final results.

The goal of mission accomplishment is designed by strategic-tactical concepts. For example, the goal of establishing an air defense group is to provide a certain level of protection for defended forces and rear-area assets against enemy air strikes. Thus, the goal is characterized by the results we are trying to achieve.

Even during this stage, it is extremely important to isolate factors which will have a significant effect on mission accomplishment and which should be taken into account. For example, for the mission of establishing an air defense group, these factors should include the firing assets of air defense systems and enemy offensive air weapons, his anticipated options, the radar surveillance pattern, etc.

It is necessary to bear in mind that it is not enough to define all the factors which will affect mission accomplishment. It is necessary to just isolate the ones which can be expressed quantitatively.

A great deal of attention should also be devoted to ferreting out limitations. By limitations, we mean the maximum performance characteristics of weapons and hardware, the maximum air defense losses and the maximum quantities of various types of materiel and technical resources and support.

An important problem is selecting the criteria, i.e., establishing the feature which will determine our preference for the alternative problem solutions being considered. The criteria is the quantitative measure of success in accomplishing the mission. With a numerical value for it, it is possible to determine how well the solution meets the requirements of objective reality. Thus, the goal of the mission must be directly reflected in the criteria or, as it is sometimes called, the target function.

The strategic-tactical description can only be successfully drawn up by well-trained officers who not only know the nature of the described mission to a tee but also the entire command and control process which includes this mission as a component part.

When drawing up a strategic-tactical description, the goal is not to compile equations and formulas which reflect the quantitative relationships. This task is accomplished when the algorithms are drawn up. However, the mission description should qualitatively express the requirement for establishing a quantitative relationship for each transaction in combat operations. Moreover, it is desirable to provide recommendations on using data from range and military tests, maneuvers or exercises.

The strategic-tactical description must be suitable for transposition into the language of mathematics even while it is being compiled. Moreover, special attention must be focused on the preliminary determination of the quantitative relationships among the parameters of air defense combat operations.

The algorithm development stage consists of formulating a mathematical description (mathematical model) of the system's behavior with a particular degree of perfection and a level of formalization appropriate to the goal. During this stage, the method for accomplishing the mission is selected based on a minimal expenditure of time on accomplishing it and minimal use of the computer memory. The algorithm is evaluated from the point of view of being able to run it on the computer and from the point of view of accomplishing the assigned mission (based on operating speed and memory capacity) as well as from the point of view of dependable equipment operation.

Algorithm development begins with the design of a comprehensive flowchart which is a combination of logical, mathematical and descriptive statements, i.e., a substantive description of the operations to be performed. The flowchart establishes the relationship among the primary operations and consists of mathematical and logical statements.

To get an idea of algorithm development, let's examine an algorithm flowchart for the task of radar data secondary processing, a flowchart which is, for example, utilized in a foreign air defense command and control system (SAGE) which covers a significant area (Figure 54).

The algorithm begins with the data input to the computer from the communications channels (block 1). In block 2, the authenticity of the message is verified by matching it against the previously established criteria. If the message is noise, it is discarded. If it is confirmed as a target message, it proceeds to block 3 where it is analyzed for adequate data in the message for further processing. For example, does it have data on coordinates or speed vectors. If there is not enough of this data in the message, it is routed to the buffer (an area in the memory unit) where it is stored until the minimum data required on this target is accumulated; sometimes, the message is transmitted further, to block 4, or, if the data is obsolete, it is discarded. An adequate message enters block 4. At this point, the target is identified based on its entering a particular gate. In block 5, the target identification is verified. If it is a false target, the message is discarded. If it is not a false target, the message is transmitted to block 6 for further processing.

In block 6, the coordinates are converted from the sensor coordinate system into the common coordinate system used by the command post processing the data.

In blocks 7, 8, 9, 10, the target is identified according to various characteristics.

If the target is tagged "foe," the message on this target is compared with data previously received by the computer to determine whether there

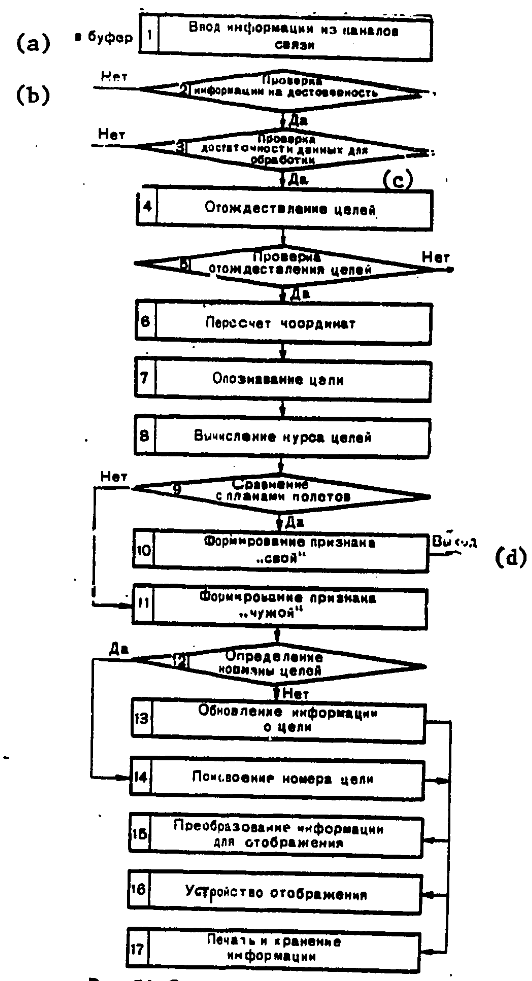

Рис. 54. Структурная схема алгоритма

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000300040017-6

Key:

Figure 54. Algorithm Flowchart

1. Data input from communications channels.
   a) To buffer
   b) No
   c) Yes
2. Data authentic?
3. Adequate data to process?
4. Identified as target
5. Target identification verified?
6. Coordinate conversion
7. Target identification [IFF]
8. Target course calculation
9. Matched to flight plan?
10. Tagged friendly
    d) Output
11. Tagged foe
12. New target?
13. Update target data
14. Assign target number
15. Convert data for display
16. Display
17. Print or store data

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is already data on this target or whether this is the first message. When the data do not match the previous data, the message is transmitted to block 14; if the data do match, it goes to block 13.

In block 15, the data is converted to make it suitable for display on a scope and block 16 transmits this message to the display. Concurrently, this information may be transferred to a printer or to the memory.

After the comprehensive flowchart establishing the relationship among specific tasks is developed, details are filled in in each of the blocks. In other words, a detailed flowchart filled with the mathematics is made up. In order for the algorithm to be processed by the computer, it is necessary to develop the appropriate program, i.e., translate the algorithm into computer language. The programming stage is the most labor intensive.

The set of instructions which can be processed by the machine is limited. For example, the machine cannot perform the instruction:

"calculate the target-kill probability when n independent rounds are fired at it." However, the machine can interpret an instruction to perform elementary, specific operations like adding two numbers, comparing them, etc. Therefore, to perform the example cited above, the machine must be programmed, i.e., given a sequence for performing the elementary operations. The mathematical model for this task can be reduced to the following formula:

$$P_n = [1 - (1-P_1)^n],$$

where P_1 is the target-kill probability for a single round;
n is the number of rounds;
P_n is the target-kill probability for n rounds.

The computer can perform the following set of operations:
1) subtract the target-kill probability for a single round (P_1) from 1;
2) access the procedure for computing a natural logarithm;
3) multiply the result of the logarithm computation by n;
4) access the procedure for computing an anti-logarithm;
5) subtract the result of the previous operation from 1;
6) print out the result;
7) cease calculations (stop).

Programming, i.e., compiling programs, consists of writing a list of sequential, elementary instructions which the machine can understand.

The set of instructions and the coding method are the so-called machine language.

There are special-purpose algorithm languages which can be used with special rules to write the program (ALGOL, FORTRAN and others). In a number of cases, there may be a requirement to translate programs into a language which only a specific type of machine can understand. For the translation, a special translation program, called a translator, is developed. The results from the translator will be the machine's operating program. The translator is an integral part of the machine's software.

A scientific approach to planning will not only increase combat readiness, it will also make it possible for commanders, staff officers and political elements to acquire very important professional and managerial skills in peacetime.

Chapter Four

Air Defense Weapons of Ground Troops and Their Combat Employment

6. Air Defense Force Employment Principles

General Principles

In the Great Patriotic War, the following basic principles were used in employing Army Air Defense forces: massing them in the decisive sectors to defend major force groupings; widespread maneuverability to concentrate air defense efforts in defending the commitment to battle of forces which would have the greatest success or which were repelling enemy counterthrusts (counterattacks); and close coordination with defended forces and fighter aviation with uninterrupted command and control. These principles are dialectically related to each other and they are mutually dependent in their implementation.

Mass. The need to concentrate air defense assets was caused by the requirement to offset the massed air threat with an effective air defense system. In the contemporary environment, this principle is still very important but with a new characteristic.

For air defense forces, mass means concentrating a sufficiently powerful group in the decisive sectors within the requisite time frame to defeat the air threat's major force. As shown by the experience of the Great Patriotic War, mass is achieved by a suitable, advance deployment of air defense weapons and by a timely change in their composition in a fluid environment. Now, with the increased range of air defense weapons, it is possible to disperse them more while, however, making it possible to use them over a greater range. As is well known, air defense assets must be dispersed to guarantee their survivability and resistance and to preclude mutual interference from the electromagnetic equipment with which modern air defense weapons are heavily saturated.

The advantages of massing air defense forces were very vividly revealed in the offensive operations of the Great Patriotic War. For example, when our forces went on the counteroffensive in the battle for Kursk (1943), approximately 50 percent of the air defense assets were concentrated in the 13th Army's area which was in the Central Front's main sector; this made it possible to establish a significant air defense density for that time--about 12 guns per km of frontage. There were higher densities in the tank armies' zones of operations. For example, the 2nd Tank Army's density was brought up to 15 guns per km of frontage; as a result, there was a significantly noticeable increase in air defense effectiveness. Over a month of fighting, the army only lost a few tanks to bombers even though the fascist German air arm carried out over 900 sorties in the army's zone during that time.

The same kind of examples also took place during the 2nd Ukrainian Front's Korsun'-Shevchenkovskiy Operation in February 1944, which, as is well known, ended with the encirclement and destruction of a major enemy formation. The most vivid success resulting from the massing of air defense forces was demonstrated while enemy counterthrusts were being repelled by the forces operating in the decisive sector (the 5th and 6th Tank Armies).

Maneuver. In massing air defense forces, a decisive role was played by skillfully employing manuever and by swift and secure execution of the maneuver. As affirmed by the British magazine RUSI, in the modern environment, the maximum range of air defense missiles increases the capability for maneuvering firepower (trajectories) with firm command and control while repelling attacks. And, this makes it possible to provide more reliable defense for the formations and assets which play the most important role in high rates of advance, the constant movement on the battlefield and the swift, abrupt changes in the situation bring about changes in the importance of defended assets. It is extremely difficult to accurately predict the headings, strike targets and strike times of enemy aircraft and it is essentially impossible to have a sufficient and permanently maintained defense density everywhere. In addition, it could turn out that air defense assets would be fighting with an adverse force ratio where the enemy has concentrated his major forces, while air defense assets would be idle or not making full use of their capabilities in sectors where the enemy is passive. Therefore, when organizing the air defense order of battle, as foreign specialists assert, it is advisable to be guided by the requirement for widespread maneuverability whose primary goal is to guarantee the most advantageous force ratio precisely in the area where the most dangerous air strikes are at a specific, concrete point in time. The mobility of the air threat should be countered by a bold, swift maneuver of air defense forces to meet the requirements of the situation.

The general requirements for a maneuver are speed, security and surprise. A maneuver should not decrease the effectiveness or combat readiness of air defense assets or of the command, control and intelligence system. During the manuever, it is necessary to rationally integrate air defense weapons with different operational ranges, guidance methods and mobility.

The experience of the Great Patriotic War has shown that a maneuver can be strategic or tactical.

The former is conducted with significant forces based on the decision of the army command group to achieve a strategic goal, for example, to transfer the air defense system's efforts to a new sector, establish superiority in the area where the air threat's main forces are operating and provide assistance to adjacent units. This does not preclude using a strategic maneuver to reinforce defense for individual tactical formations, for example, for corps or division-level units which are having the greatest success in the offensive, are advancing for commitment to the engagement (battle) or are advancing to deliver a counterthrust (attack) and are, therefore, accomplishing an important mission for the success of the operation. The spatial scope of the maneuver is determined by the distance from the maneuvering air defense forces' disposition to the area of their commitment to action.

The tactical maneuver is conducted with more limited forces, frequently within a division, battalion or lower level unit, to accomplish a tactical mission. The typical tactical maneuver is concentrating or dispersing efforts during the air battle, i.e., maneuvering firepower or changing air defense unit positions, retargeting airborne fighters or relocating radar sites. A maneuver of air defense forces is also frequently conducted to confuse the enemy about the true composition.

During the Great Patriotic War, the maneuver and a change of positions were executed to decisively reinforce the defense for the formation which was accomplishing the most important mission, presented the greatest threat to the enemy and was the one that he tried to deliver especially heavy air strikes against. During specific periods of an operation, some armies had 4-5 ADA divisions each. For example, between 14-15 February 1945, the 5th Shock Army--within whose area the main thrust was delivered had 5 ADA divisions; later, 2 were regrouped and sent to other sectors which were marked for the success of the operation. Several air defense divisions were transferred from one army to another several times during an operation.

During the operations in Belorussia (1944), 60 percent of the 1st Baltic Front's air defense assets were sent to the 6th Guards Army which delivered the main thrust at the outset. The 1st Belorussian Front continually maintained a reserve of 1-2 ADA divisions which maneuvered to defend particular assets. A large role was played by maneuvering ADA to defend crossing sites and bridgeheads. At the Magnushevskiy bridgehead, 4 ADA divisions and 2 regiments were concentrated on a narrow front (24 km). In addition, they were immediately adjacent to the operational area of a Polish Army Air Defense division.

Based on the method of execution, we can distinguish a maneuver in the air space, which consists of changing the direction or area of operations for the air defense assets which are accomplishing the mission of defending the forces within their area of coverage without any change in position or airfields, and a maneuver with a change of position. The employment of a particular type of maneuver is dependent upon the situation and the operational characteristics of the air defense assets. An important criteria in selecting the type of maneuver is the time required to conduct it. When the situation is extremely tense and fluid while repelling an attack, the maneuver is primarily conducted without any change in position, with the exception of those weapons which are able to fire on the move or at a short halt and man-transportable air defense missiles.

For air defense weapons, a maneuver in the air space means a maneuver of trajectories or, in other words, fire adjustments. In past wars, fire adjustments were executed for ADA by concentrating or dispersing fire; but, due to the short range, it was primarily of tactical importance. With the advent of air defense missiles, there was a significant expansion in the capability for fire adjustment.

Foreign specialists believe that a tactical maneuver with a change in position by units is one of the basic elements of combat operations for short range air defense weapons which are defending units directly on the battlefield. The weapons for direct defense will maneuver frequently within the ADA zone established by the longer-range ADM's. These zones are relatively stable; however, they will also gradually shift as the defended forces change locations. The foreign press has indicated that it is relatively easy to locate launch sites during a missile launch. Therefore, in addition to site camouflage and maximum concealment for air defense weapons, an effective defensive measure for them will be their ability to rapidly move to alternate sites in order to guarantee their survivability.

Due to Army mechanization and motorization, high mobility standards are being set for direct support air defense weapons. The problem primarily consists of the fact that, as a result of the fluid fighting, there are rapid changes in defended assets. Therefore, there are requirements for high tactical mobility in air defense and for flexible thinking by air defense commanders. Direct air defense forces must be able to fire on the move, at a short halt and also be able to rapidly deploy into position from the march and immediately be brought up to combat readiness. In the opinion of foreign military specialists, this makes it necessary to have self-propelled air defense guns able to fire on the move and from a short halt for air defense of combined arms divisions (units).

In combat, air defense weapons are used on a centralized basis which takes into account the employment of air defense units that senior commanders have. At the same time, the nature of modern combat and the presence of organic air defense weapons directly at the disposal of combined arms unit commanders requires decentralized warning for the weapons.

During the Great Patriotic War, even maneuvers of small ADA forces were frequently conducted and this was justified. For example, to defend railroads, rail junctions and bridges which were of vital importance to Front and Army operations, there was widespread deployment of mobile ADA groups. They primarily operated from a floating ambush. The groups usually contained one to two Degtyarev-Shpagin heavy air defense machinegun platoons and a light ADA platoon (two to four guns). The firing positions were selected in the probable directions of enemy aircraft and they were changed periodically. This made it possible to defend two to three times the number of small, but very important, point targets during the most important period of intense fighting.

For example, during the preparations for the April-June 1943 operation in the Kursk Salient, fascist aircraft conducted several large-scale attacks against the Kursk, Kastornaya, Marmyzhi and Okhochevka rail junctions and against the major bridge across the Tim River. But, due to a timely ADA maneuver, the enemy was not able to paralyze our major rail lines which were concentrating forces.

Air Defense Employment Under Various Combat Conditions in Foreign Armies

The law on the interrelationship between material assets for war and the methods for waging it is considered one of the most general laws of warfare because it operates both for the war as a whole and for all types of combat operations. Since the various types of combat operations have their own special features, the impact of this law on each type of combat operation has its characteristic features. During recent years, the methods for conducting combat operations have been brought into conformity with the more modern materiel and equipment and the increased morale and fighting efficiency of personnel.

V. I. Lenin wrote: "...each engagement contains within itself an abstract possibility of defeat and there is no other way of reducing this possibility than by making well-organized preparations for the engagement."* Based on this principle, successful air defense deployment is dependent upon thorough air defense preparations and organization which considers the characteristic features of various combat conditions.

In the offensive, modern Army units and formations can advance over significantly greater areas than previously and to a greater depth; this has a direct effect on the organization for and conduct of air defense.

For example, judging from the experience of a number of NATO exercises, the frontage of the division's zone of advance and the depth of its combat mission have increased four to five times compared to the last world war. For example, the frontage of the division's zone of advance will be 20 km or more; for the corps, it will be 60-80 km and, for the field army, it will be 200 km. The mission assigned to the field army on the offensive can be to a depth of 150-180 km, i.e., it may include routing the enemy's first echelon and his immediate tactical reserves. The rate of advance is 40 km per day or more.

* Lenin, V. I. "Poln. sobr. soch.," vol 6, p 137.

The air defense mission will depend on a number of factors. The conditions of the transition to an attack will have a significant effect. An attack can be conducted from the march or from close contact.

While forces are being moved up and deployed for the attack, an air strike would be very dangerous and the primary mission of air defense will be to provide dependable defense for the main force grouping.

During an attack from close contact, it is necessary to deny the enemy aerial reconnaissance, keep him from discovering the regrouping and provide especially dependable defense for the forces in the breakthrough sector.

During the last war, the primary efforts of the assigned (an army ADA regiment) and attached ADA (an ADA division and an independent AD battalion of the Supreme High Command Reserves) were concentrated in the 65th Army, Don Front, (January 1943) breakthrough sector of the encircled enemy's defense near Stalingrad. Although the ADA group was defending the first echelon forces and artillery within a limited area (a frontage of 8-12 km and a depth of 6 km) with a density of only 9-10 air defense guns and 7-8 air defense machineguns per km of frontage, even under these conditions, the group established multiple layers of air defense fire which made it possible to inflict heavy losses on the air threat in conjunction with fighter aircraft and to provide dependable defense for the attack group (Figure 84).

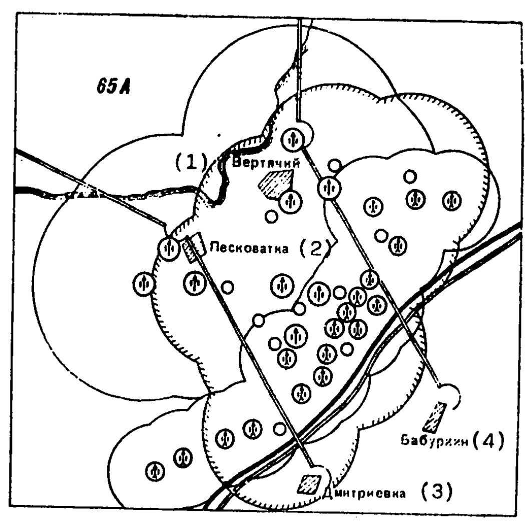

Figure 84. 65th Army ADA Group at Stalingrad (January 1943).

Key: (1) Vertyachiy
(2) Peskovatka
(3) Dmitriyevka
(4) Baburkin

The air defense machinegun units were deployed within infantry formations at a distance of 500-600 m from the FEBA; the light ADA batteries were 1-1.5 km from the FEBA; and the lead medium ADA batteries were 2-3 km from the FEBA. During the counterattack and defeat of the Stalingrad group by our forces, air defense weapons destroyed 273 enemy combat aircraft and transports.

During the offensive, foreign military specialists believe that it is important not to allow air defense forces to be split up; therefore, primary attention should be focused on defending tank and mechanized attack groups especially in defiles and at river crossings where the air threat can inflict the greatest damage. In a fluid attack, there is a requirement to direct air defense efforts to accomplish missions which arise during combat operations in a timely manner, for example, to defend the second echelon and reserves when they are being brought forward and committed to the engagement and to defend forces which are repelling counterthrusts and routing the enemy's rear-area reserves.

A characteristic of the operations of the Great Patriotic War was that, during the offensive, there was a decisive reinforcement of the defense for groups which were carrying out the most important missions or which presented the greatest threat to the enemy, the groups that the enemy tried to destroy with large-scale air strikes. At specific times, some armies were reinforced by several ADA divisions. In the operations during the final period of the war, we established high densities of 30 or more air defense guns per km of frontage in a narrow sector and this made it possible to effectively repel attacks against the main force groupings.

The experience of the Great Patriotic War shows that special attention was focused on defending the forces which would have the greatest success during the offensive. For example, on 12 August 1941, the 34th Army, Northwestern Front, successfully began an attack from Staraya Russia; over a 2-day period, it advanced to a depth of 60 km and threatened to encircle the enemy's Novgorod group. However, the ADA defense was not sufficient. In addition to reinforcing its land forces, the fascist German Command focused the primary efforts of the VIII Corps dive bombers in this sector. Not meeting the proper resistance from air defense weapons, the enemy aircraft inflicted heavy losses on the 34th Army and disrupted its command and control. Our units reduced their rate of advance and, later, they completely stopped offensive operations and went over to the defense at the Lovat' River.

Abroad, they believe that the evolution of modern offensive operations, which are at times characterized by head-on engagements developing simultaneously over a great depth, and the expanded zones of advance will require air defense, while maintaining an overall centralized air defense system to defend dispersed groups by properly distributing its efforts and maneuvering in a timely manner throughout the area of responsibility, by combining area and point defense and by using fighter aircraft, to defend the gaps between army groups.

In the opinion of NATO specialists, ADM units must be quickly transferred from their fixed dispositions to field positions right before the transition to the offensive. For the first Hawk missile belt, provisions are made to have these positions 10-12 km from the line of contact at a distance of 10-35 km from each other. A battery is distributed over a 300 by 400 m area.

Plans call for locating the Nike-Hercules missile batteries far behind the line of contact, i.e., behind the Hawk missile positions. These missile units are used to defend major force groupings and important rear-area assets. It is evidently believed that the most favorable environment for setting up an area defense will exist during the preparations for the operation and at the outset of the operation.

For defense of forward area units, a number of foreign armies attach a great deal of importance to self-propelled and man-transportable air defense units as well as to self-propelled ADA. With their own radar support and fire control, these units will be able to operate autonomously of the primary air defense command and control centers. ADA and air defense machineguns are deployed at defended points or near them.

For example, self-propelled 40-mm air defense guns may be deployed around an individual point target at a distance of 100-800 m from it while large air defense machineguns may be deployed 100-350 m from it. Short range air defense missiles and man-transportable systems are deployed within unit formations.

Foreign specialists believe that, during the offensive, air defense weapons are required to provide defense for land forces by not being separated from them at a distance greater than effective firing range. ADM units for area defense change positions, as a rule, by order of the higher commander. However, unit commanders are required to make suggestions on changing battery locations after evaluating the situation. The move to new positions is conducted by battery; moreover, each subsequent battery should begin to move from its old position after the previous battery is ready to fire in the new area.

It is believed that the relocation of air defense weapons in an offensive should consist of coordinating their locations with the location of the defended forces so they do not get separated from them and weaken the defense. In itself, the relocation is not a maneuver in the true sense of the word since the weapons allocations and missions do not change. However, a relocation frequently can actually merge into a maneuver since the new missile sites may create a different air defense weapons group.

While defending the 2nd Guards Tank Army in the Vistula-Oder Operation during the Great Patriotic War, the 24th ADA Division changed positions 34 times during 2 weeks of fighting while reorganizing. On some days, the division completely changed its combat formation six times.

The foreign press points out that the high rates of advance raised a critical problem for air defense forces in changing positions at the defended forces speed without reducing their combat readiness and without weakening their coordination with fighter aircraft. It is also necessary to move surveillance assets to new positions rapidly in order to shift target coverage as far forward as possible.

If air defense is weak in an area, for example, when a certain number of air defense missile systems are moving to new missile sites, the reduction must be compensated for by a fighter aircraft maneuver.

The methods of relocating air defense units during an offensive depend upon the situation, the mission, the rate of advance of defended forces, the size of defended areas and a specific system's own maneuverability.

Three methods of relocation may be used for first echelon defense:

1. By phase lines as a unit;

2. A sequential relocation, i.e., by individual small units while maintaining uninterrupted defense and guaranteeing that when the forces exit from the area defended by the small units remaining in the old positions, the relocated air defense units will already have set up in new positions;

3. With the defended forces in their battle, march or approach march formation, ready to fire on the move, at a short halt or by setting up.

Abroad, the main force groupings are usually defended by an area air defense system; however, regardless, close-in defense is organized by organic weapons, primarily for low altitudes. During the offensive, the low-altitude air battle can be extremely fierce. Using low altitudes, enemy aircraft can unexpectedly deliver strikes against battle formations. ATGM-equipped fire support helicopters present a serious threat to penetrating armored forces.

The battalion uses air defense gunners (armed with the man-transportable missile systems) for air defense and it prepares small arms volume fire. If the battalion has an attached self-propelled air defense battery (platoon), its battle formation is coordinated with the deployment of the air defense gunners to guarantee coverage of the air threat in the most likely sectors.

The battery deploys in a single site or by platoons. The battery (platoon) and air defense gunners are assigned target engagements and surveillance sectors of responsibility. Two options for battalion air defense weapons deployment are shown in Figure 85.

With a breakout attack from the march against a defending enemy, air defense weapons must rapidly take their places in battalion column when it

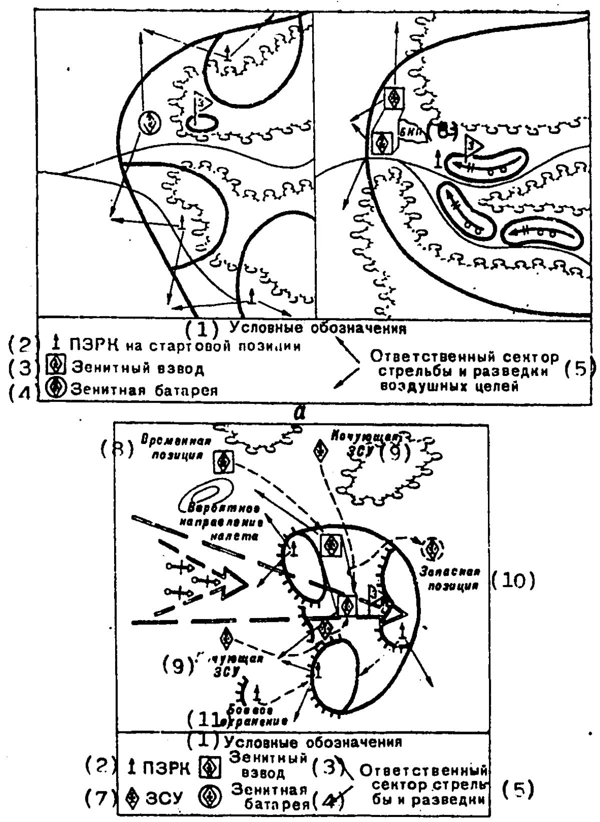

Figure 85. Mechanized infantry battalion air defense weapons (Type) Deployment: a - offense; b - defense.

Key:
(1) Legend
(2) Man-transportable missile launch position
(3) Air defense platoon
(4) Air defense battery
(5) Target engagement and surveillance sectors of responsibility
(6) Battalion CP
(7) Self-propelled ADA gun
(8) Temporary position
(9) Floating self-propelled ADA gun
(10) Alternate position
(11) Security

is moving up to the jump-off line. To insure the best communications between the battery (platoon) commander and the battalion commander, it is considered advisable to put the air defense battery (platoon) in the column of the company that the battalion command-observation post is relocating with and the battery commander should travel with the latter.

As the battalion begins to deploy at the jump-off line, the air defense battery (platoon) takes up a position which is coordinated with the air defense gunner tactics. During the attack, the battery (platoon) relocates without any separation between the air defense guns and the defended unit. They maintain uninterrupted radio communications.

During an attack from close contact with the enemy, the battalion commander usually spells out the employment procedures for the attached air defense battery (platoon), the air defense gunners and small arms fire after reconnoitering and sizing up the terrain and probable sectors for enemy air strikes. Procedures for relocating air defense weapons during the fighting are outlined.

During the attack, the air defense battery may receive a mission to maneuver in order to defend the second echelon battalion when it is committed to battle. The battery commander must establish communications with the commander of this battalion, relocate his platoons and take up a battle formation until the battalion arrives at the jump-off line.

When engaging helicopters, it is first necessary to consider the fact that they can operate at altitudes of 15-30m and they may be in the zone of fire for a short period of time. During this brief period, the air defense unit must detect the helicopter, slew its gun toward the target, pick up the target and fire on it; well-organized aerial surveillance and a high level of alert are required for this. Based on terrain conditions and the combat environment, it is important to correctly determine what the helicopters' course might be or where they might be lying in ambush. If required, it may be necessary to relocate air defense units so that the helicopters will probably appear within the effective range of the air defense weapons.

It is most difficult to engage helicopters which are firing from friendly territory. This is where the young commander's role and initiative are especially important. He must carefully monitor terrain masking which the helicopters may use for cover and he must calculate the data required in advance for firing based on appropriate landmarks. When attacking the enemy's main line of resistance, direct support air defense weapons must move behind the tanks without any separation.

The most mobile air defense weapons should be earmarked to defend tank units.

In the 1943 Orlov Offensive Operation, the 3rd Guards Tank Army and its attached ADA division had 102 air defense guns and 304 large air defense machineguns. During the attack and regroupings, there was a sharp reduction in air defense since the air defense weapons were traveling along the roads. To compensate somewhat for this, hull machineguns were installed on the tank turrets and adjusted for antiaircraft fire in a number of tank brigades. Although their effectiveness was not high, the massed antiaircraft fire over the tank column forced enemy aircraft to increase their altitude and this cut down the opportunities for precision bombing.

Second echelon and reserve commitment to battle is one of the major events during an offensive. It is completely logical to expect that the enemy will try to disrupt it in every way possible. Therefore, to defend the forces being committed, it is necessary to concentrate the greatest number of air defense weapons. The defense of forces meeting enemy counterattacks will also require special attention; as a rule, it will be necessary to maneuver air defense weapons in order to reinforce the defense of these forces.

For example, during the 1st Belorussian Front's offensive in February 1944, the enemy made a number of air strikes with up to 200 aircraft in the 3rd Army's area in the Rogachev-Bobruysk sector during the enemy counterthrust. With a determined concentration of ADA from secondary sectors to the decisive sector, the enemy was faced with an increased air defense density--24 guns and 19 machineguns per km of frontage. As a result, after losing 29 aircraft, the enemy was forced to give up any further strikes.

By maneuvering during the Great Patriotic War, we were able to guarantee surprise employment of ADA. For example, in the same operation by the 3rd Army, a secret move forward and deployment by an ADA group was implemented in difficult terrain with a security screen and under cover of darkness in a defile between the lakes. Enemy aircraft attempts to deliver strikes against the 3rd Army's forces which were advancing in the major sector were disrupted by the large-scale, surprise antiaircraft fire. During a single day, the enemy lost 28 aircraft, i.e., 25 percent of the aircraft which were delivering strikes against the army.

One of the reasons for the serious failures of Anglo-American forces during the German counteroffensive in the Ardennes in December 1944 was the weak air defense which resulted from their violation of the principle of concentrating air defense forces in the decisive sector. With large-scale strikes against the major Anglo-American force grouping, the fascist German aircraft inflicted significant losses on them, disrupted command and control, demoralized their personnel and brought them to the verge of catastrophe.

During an offensive, forces will sometimes have to conduct river crossings.

When making a forced crossing of a large river, especially from the march, air defense reinforcements will play an especially important role. Although steps will be taken to avoid excessive bunching of men and equipment on approaches to the river, the crossing forces may nevertheless present suitable targets for air strikes.

In his memoirs, MSU A. M. Vasil'yevskiy cites a 28 September 1943 Headquarters Supreme High Command directive which was received while our forces were crossing the Dnepr River. It stated that it was necessary "to immediately bring air defense weapons up to the crossing sites and provide reliable protection both for the battle formation making the crossing and the crossing sites themselves against enemy air strikes, regardless of the number of forces making the crossing."

This example is evidence of the serious importance given to air defense during river crossings by the Red Army's highest headquarters.

During the remainder of the attack, air defense forces defend the major force groupings which are fighting the enemy's approaching reserves in order to defeat them, seize defensive lines in the enemy's rear area and accomplish other missions assigned by the headquarters. During this period, major emphasis must be put on defending logistics and extended lines of communication.

Meeting engagements, which are characterized by their unexpectedness and rapid transition into other types of combat operations, may be engaged in by organic units, as a rule, by deploying the main body of forces from the march when close contact is preceded by closure in march formation. The entire organization for battle and the establishment of air defense will be implemented within extremely limited time frames under enemy action. Units moving forward in individual directions may engage simultaneously; both sides' exposed flanks will increase the opportunities for aircraft movements.

Meeting engagements will usually unfold in unimproved terrain when forces are out in the open and there is an increased danger of air strikes; this puts a great deal of responsibility on air defense forces to move forward and set up in their assigned areas in a timely manner. The primary air defense efforts must be focused on defending formations which are deploying and delivering the main thrusts against the enemy. The enemy will also try to attack; because of this, the main body of the forces will be the target for the major part of the offensive air at the enemy's disposal; this is what causes the ferocity of the air battle in meeting engagements and it increases the role of air defense.

Since the fight for the initiative in meeting engagements begins on distant approaches with missile strikes and the employment of aircraft and long-range artillery, the most important mission for air defense at the outset of a meeting engagement by advance units will be to provide dependable defense for columns and march formations and to deny the enemy aerial reconnaissance.

If the forward movement is being covered by units operating ahead, it is necessary to use intelligence data on the air threat from forward air defense units (small units). If there are no forward units (small units), it is necessary--under cover of advance units--to move forward and deploy the amount of mobile radar equipment required to guarantee reliable coverage of the air threat on approaches to force deployment lines. When the situation is vague--which is typical at the beginning of a meeting engagement--there is an extremely serious threat of a surprise air strike; this makes it necessary to set up and conduct reconnaissance in all units (small units) with all available equipment.

At the same time that combat operations begin, advance units will be deploying in battle formations primarily from column formations. Therefore, the degree of readiness and mobility of the available direct support air defense weapons becomes especially important.

The proper distribution of direct support air defense weapons to columns plays a decisive role.

During the march, all attached air defense guns and air defense gunners traveling in tank, motorized rifle, missile and artillery unit columns will be put on alert to open fire immediately in their sectors when defended forces are passing through bottlenecks (bridges, river crossings, defiles, etc) and when they arrive at probable lines of contact with the enemy. The commanders organize air surveillance, especially of terrain masking and areas which may provide cover for enemy fire support helicopters and which can be used for low-flying aircraft approaches.

When there are low-altitude enemy air strikes or when fire support helicopters attack from ambush, air defense systems may fire from the march or from a short halt; maximum use will be made of the capabilities for firing from air defense machineguns on tanks and from small arms. Systems which cannot deploy rapidly will continue to move after stretching out the column and increasing speed. If warning is received in advance, they should be deployed. In coordinating with defended forces, it is very important for air defense units to get cover from enemy mobile units since the vague situation at the outset of a meeting engagement is a favorable environment for their operations.

In the defense, one of the major requirements is to provide reliable air defense protection, i.e., the capability to withstand a large-scale strike by offensive enemy air.

The transition to the defense may occur from close contact with the enemy or without contact; however, in all cases, there is an air threat. The defense can be used to win time, conserve forces, consolidate and also to meet an attack by superior enemy forces with strong air support.

According to opinions abroad, modern defense is based on a combination of stubbornly holding on to major areas (lines), fluid army operations and defeating the enemy with fire strikes and counterattacks (counter-thrusts). The forces will occupy the most important (key) areas and improved positions in the main sectors; they will be spread out along the front and especially in depth. For example, a NATO division's depth in the defense will reach 30 km; the width of the defensive zone will be 25-30 km (at the end of World War II, a division occupied a defensive zone of 10-15 km with a depth of 6-8 km). A battalion in the defense presently occupies a frontage of 5 km and a depth of 2-3 km.

The typical defense will not have a continuous front and there will be gaps between elements; because of this, air defense weapons must defend forces over a larger area.

When there is no close contact with the enemy, a number of foreign armies plan to establish a 25 km or deeper security zone. The division's zone of defense will consist of the forward defended area of the first echelon brigades (with a depth of 6-8 km) and the division reserve area (20 km or deeper). Tactical reserves will be positioned at a greater depth--100-150 km or more. Since the attacking side can develop high rates of advance, the time for organizing the defense and establishing air defense will frequently be extremely limited.

During a hasty transition to the defense while attacking or as a result of an unsuccessful outcome of a meeting engagement, the time for organizing the defense and air defense of it will be even shorter.

The transition to the defense without contact can be implemented in secondary sectors and on seacoasts. This also applies to second echelons and reserves; there will be a more favorable environment for organizing the defense; however, there will still be an air threat due to the long range of offensive air. Consequently, an equally high degree of combat readiness will be required of air defense.

The transition to the defense while attacking frequently will not occur at the same time for different units; it may occur while enemy land and air attacks are being met, under the influence of his thrusts, while taking losses, with contaminated terrain and damage or with operations by airborne assault forces which the enemy will try to drop (land) in the rear.

The top priority air defense mission will be to defend units which are transitioning to the defense or regrouping. Under these conditions, there will be an increase in the role and importance of air defense unit flexibility and mobility, their rapid and secure movement and organizing battle formations which guarantee dependable defense.

As stated in the West German magazine WEHRKUNDE, the most important mission for air defense weapons in defensive engagements will be to provide priority defense for artillery (especially nuclear artillery) and the mechanized and tank groups earmarked for a counterthrust.

It is anticipated that radar surveillance of the air threat will be conducted continually by deploying backup radar sites in sectors where gaps have appeared in the continuous radar coverage and by skillfully combining centralized deployment of radar sites and air defense unit radars. Special attention is being focused on maintaining continuous, low-altitude radar coverage. The British magazine RUSI (March 1973) reported that the enemy will have an urgent requirement for aerial reconnaissance during an offensive. This must be taken into account when organizing for air defense to avoid a premature disclosure of the friendly defensive system. If the enemy's aerial reconnaissance is not countered, it will be very difficult to concentrate forces for surprise counterattacks.

Foreign military specialists believe that the idea of using air defense weapons to defend the group delivering the counterthrust should be the foundation for deploying air defense weapons when the defensive group is first established. It is advisable to assign missile deployment areas for a number of air defense units in such a manner that they will be able to defend the forces delivering the counterthrust--and at tactical echelons, the forces delivering the counterattack--with only a slight regrouping.

Air defense missiles are arranged to provide the most dependable defense for the main force grouping in the probable sector of the enemy's main thrust. Preparations are made for widespread air defense maneuvers, operations from ambush and operations by floating units. When force dispositions are relatively secure and when they have some time at their disposal, it is necessary to use it to prepare for air defense maneuvers and to improve routes, alternate missile sites and secure command posts.

Air defense in the last war provides a number of examples of maneuvers to defend forces in the sector of the main thrust. For example, in the defensive engagement at Kursk (1943), a maneuver brought the density in the sector of the enemy's main thrust up to 2 medium ADA guns, 7 light ADA guns and 7 Degtyarev-Shpagin machineguns per km of front by 7 July while it was not even half this number on 5 July. By 9 July, 4 ADA divisions and 4 army air defense regiments were concentrated on a 36 km frontage and to a depth of 8 km. Due to this massing, the Central Front's ADA inflicted irreplaceable losses on the enemy over a 7-day period: it destroyed 25 percent of the attacking enemy aircraft. In addition, ADA decisively undermined enemy air force actions.

In the engagement at Prokhorovka, the density of ADA coverage was increased to 12 guns per km of frontage along a 20 km front with a depth of coverage of 7-8 km by 12 July. They prepared 25-30 percent of the medium machineguns and antitank guns for the low-altitude air battle; among the forces located in the rear, it even reached 40-50 percent. In addition, volume small arms fire was used.

The experience in setting up surveillance of the air threat is also instructive. In the Kursk Battle (1943), air warning service sites were deployed at Front, army, corps and division command posts, at fighter airfields and in each rifle division on the FEBA. In addition, rifle regiments established non-TO air warning service sites.

In the modern defense, as well as in the offense, units organize direct support with authorized and attached air defense weapons and they also prepare for volume small arms fire against low-flying enemy aircraft and helicopters.

For example, a battalion may be located in the first or second echelon or it may carry out the role of an advance unit in the security zone. The attached air defense battery may be assigned primary, alternate and temporary positions.

The temporary positions are earmarked for firing against targets until enemy land forces begin their attack in order to make it difficult for him to discover the true defensive organization. It is necessary to establish procedures for air defense guns to return to their primary from the temporary positions.

A possible option for deploying battalion air defense weapons in the defense is shown in Figure 85, b.

Engineer improvement of the firing position is very important for maintaining the air defense unit's combat capability in the defense.

When the firing position is occupied, surveillance is established first in case of a surprise air or land threat. Then, they make slit trenches for personnel, weapon pits for the air defense systems, shelters for prime movers and ammunition, slit trenches and foxholes for the grenade throwers and soldiers. Antitank mines are laid in areas that tanks can pass through.

When organizing for defense of a seacoast, coordination with naval air defense assets is especially important.

During an airborne assault, air defense is extremely important.

Frequently, forces are prepared for an assault at a certain distance, sometimes an extremely great distance, from the front lines, but within range of offensive enemy air. When preparing for an assault and during the assault, the most important air defense mission will be to defend the transport aircraft which are especially vulnerable from the air. It is also important to protect the assault force from the air threat during embarkation when the forces and transports are concentrated at embarkation airfields. After the assault force is dropped (landed), it will be necessary to concentrate air defense efforts on protecting the assault force which will represent a number of individual, usually mobile, point targets dispersed over a large area.

When the assault loading zone is far in the rear, air defense weapons and fighter aircraft from the National Air Defense Forces may be used to defend it. In addition, before embarking on the aircraft, the assault force's organic short-range air defense weapons should be used. Air threat warning for the assault force should be provided by the radar surveillance operating in that area.

If the embarkation area is located closer to the front lines, the possibility of tactical air strikes against it increases. Therefore, it is necessary to reinforce air defense of the area, right up to allocating special-purpose air defense weapons by moving them to other sectors (point targets) to establish the defense. Short-range ADM's and light ADA should be positioned near troop dispositions and embarkation airfields for close-in cover. However, close support air defense weapons should not give away the locations of defended assets. Restricted operational modes are established for these weapons, air defense alert units are designated and fighter protection is increased.

While flying over friendly territory, the assault force is protected by fighters and by air defense weapons located along and near the flight path. When flying over enemy territory, in addition to neutralizing enemy fighters, foreign specialists recommend that enemy air defense weapons and electronic systems be suppressed with jamming and suppressive strikes.

It is most difficult to defend the assault forces after they are landed (dropped) and while they are conducting combat operations in the enemy's rear. At this time, the entire burden of the air battle shifts to the assault force's organic air defense weapons. It is advisable to land them as part of the first wave to defend the transports' landing sites and subsequently, to defend the forces engaging in combat operations on the ground.

Air surveillance may be accomplished by the electronic equipment arriving in the drop zone with the assault force and by aircraft. Each of the assault force's units and all its command posts will establish air surveillance sites equipped with optical gear, radio communications and alerting equipment.

Amphibious assault of land forces operating in maritime sectors may be carried out in conjunction wit' the Navy's amphibious assault landings to seize continental coastal areas, islands, enemy naval bases and other coastal objectives.

Regardless of its scale, an amphibious assault landing consists of several phases: embarkation on ships, sealift of the assault force and landing on the beach. Afterwards the landed force is supported until the amphibious assault operation is over, i.e., until it has transitioned to a combined arms battle conducted on dry land by the Army headquarters.

During World War II, it was discovered that the success of amphibious assault landing operations was highly dependent upon the reliability of the air defense for them.

During the Allied amphibious assault operation in Sicily in July-August 1943, instead of destroying the enemy, shipborne ADA shot down over 30 of its own loaded troop transports because of a lack of uniform guidance and poor air defense organization. During the landing in Normandy in June 1944, Allied air strikes inflicted severe losses on the 6th British Airborne Division which had landed northwest of Cannes. The results were different in April 1945 when the 11th Guards Army also used an amphibious assault to defeat the remnants of the enemy's East Prussian force at Frisch-Nierung Spit. The well-organized coordination with advancing army formations and sufficient protection for the landing force from the air played a positive role in the success they achieved.

Coastal air defense must insure a maximum, seaward displacement of defended areas by moving air defense weapons closer to the water's edge and by positioning radars and air defense weapons in such a manner that a 360-degree defense is maintained for the landing force in case the air threat approaches from the interior.

The time that the amphibious assault force spends in embarkation areas and in transit has a significant effect on its chances of being hit from the air; therefore, it is necessary to increase the pace of embarkation, reduce the landing force's transit time and carry out the landing within a compressed time frame.

In NATO naval training, specially-designed, high-performance landing ships are used to reduce transit time; these ships can use the "shore-to-shore" principle (without loading the assault force on assault landing craft). To reduce landing time, forward elements have amphibious armored personnel carriers, tanks and other amphibious landing craft; helicopters are used on a widespread basis and airborne assault landings are used.

As the distance from the friendly shore increases during transit, the environment for the fighter escorts, which is limited to the aircraft's operational radius, becomes worse. There will be a significant decline in air defense missile coverage and an increase in the probability of enemy air operations at low and very low altitudes. The proper distribution of shipborne missile systems for cruise formations and skillful employment of the assault force's air defense weapons deployed on the troop transports will be of exceptionally critical importance.

In addition to protecting the most important elements of the cruise formation, the distribution of air defense systems on the transports must provide the most favorable environment for the air defense units to swiftly disembark and deploy on the beach.

Units must have a certified supply of spares, tools and accessories to replace units and subsystems of equipment components which fail. Maintenance men and repairmen must be efficiently distributed among the transports.

During the final stage of the amphibious assault landing operation (combat operations on the enemy's beach), the landing force's air defense weapons deploy in series. At first, during the landing battle, the air defense unit of the advance elements deploy, providing a forward echelon of air defense.

The air defense group will be built up as the main body of the assault force lands. The first wave's air defense weapons deploy along with it and, then, the weapons of the remaining land force units deploy.

Ship-based air defense weapons of the assault landing support force will operate in the coastal area, reinforcing the seaward defense for the second wave's landing and for the assault landing force's logistics units.

A force regrouping, no matter what method is used for it, there will be a danger of air strikes. In addition, in spite of enhanced troop mobility, the destruction of targets supporting movement (road junctions, bridges and other road facilites) by enemy strikes may severely complicate and, at times, even disrupt the regrouping. Therefore, protection of forces during regrouping and protection of road assets will be major air defense missions. Since the enemy will be actively conducting aerial reconnaissance to locate strike objectives and to disrupt the regrouping, it becomes very important to destroy his reconnaissance aircraft to keep them out of the areas of troop movements.

In addition to allocating special forces to reinforce air defense for regrouping forces, especially at river crossings and bottlenecks, it is necessary to make maximum use of authorized and assigned air defense weapons and of small arms fire.

Under certain conditions, units will go into retrograde. In conducting deliberate retrogades, units usually deploy sequentially and conduct combat operations at intermediate lines and at the final line.

The basic missions for air defense assets will be to protect the main force grouping during its disengagements, while it is crossing rivers and bottlenecks and while it is conducting operations at the lines mentioned above. Air defense weapons and radar relocation procedures are coordinated with the times of withdrawals; moreover, it is necessary to establish reliable air defense for the rear guards which are covering the withdrawal of the main body of forces in order to keep the enemy from delivering air strikes against the rear guard and, thereby develop conditions for pursuing the units in retrograde. Since a significant part of the air defense missiles may be on the move, it is necessary to increase fighter cover.

The experience of World War II shows that, during retrograde, especially during a forced retrograde movement due to an unsuccessful engagement, the organization for air defense will be extremely difficult.

During the Crimean Front's retrograde movement in May 1942, they received poor air cover and suffered heavy losses as a result. The evacuation of units from the Crimea to the Taman Peninsula was conducted under difficult conditions because the crossing site was subjected to heavy bombing in the absence of appropriately organized air defense.

During operations in special environments (mountains, desert, arctic), special operating peculiarities and specific environmental factors--such as, weather, temperatures, roads and others--will have a direct effect on the organization for air defense.

The general, special operational peculiarities include operations in separate, barely accessible, extremely spread out and frequently isolated sectors and lower rates of movement.

The spread out, deeper disposition of reserves will require them to organize their own defense both in their dispositions and when moving forward for commitment to battle.

In mountainous areas, it is necessary to reinforce the defense of narrow passages (bottlenecks), passes and river crossing sites; in desert areas, it is necessary to reinforce the defence of oases and sources of water. In barely accessible terrain where specially equipped forces are used, widespread use of light, transportable missiles and air defense machine-guns will play a large role.

In addition, it is necessary to consider the effect of local conditions on the operations of air defense equipment and personnel.

In mountainous areas, the rugged terrain and the masking effect of the mountains will reduce the range of target coverage. The limited road system and difficulty in traveling will make it necessary to increase engineer support in relocating air defense forces.

Air defense ambushes and floating air defense units may be set up; air defense gunners may be positioned on high points. During the Korean War (1952), groups of the Korean People's Democratic Republic fighting men armed with heavy machineguns and small arms inflicted heavy losses on American aircraft from the hills. In the modern environment, the largest air defense missile systems may be positioned on a plateau or deployed in depth along roads, ravines or riverbeds. For example, during the Great Patriotic War, ADA batteries were positioned along the roads and valleys of mountain streams during the 1942 fighting in the Tuapse sector of the Caucasus.

In desert areas, it is necessary to consider the harmful effect of sand and dust on military hardware and personnel. It will be extremely difficult to camouflage or conceal equipment and men (camouflage paint on equipment and vehicles will be required) and it will be extremely difficult to set up improved positions. It is necessary to focus special attention on organizing low-altitude air defense. Problems of a general nature will be posed by difficulty in supplying water and high temperatures; this will necessitate special measures, special personnel training and special gear.

In northern (arctic) areas, it will be necessary to take special steps to reduce the effect of fluctuating weather conditions and the special features of arctic days and nights; it will also be necessary to consider the proximity of the magnetic pole and the frequent magnetic and ionospheric storms as well as the low temperatures, snowstorms and snowdrifts. The exposed flanks and large empty gaps between the areas occupied by units will require organizing continual security for air defense assets, especially during the arctic night, in snowstorms and in fog.

Conclusion

It is generally accepted that, in modern warfare, the outcome of army combat operations will be greatly dependent upon the army's capability and ability to successfully wage an intense, highly fluid air battle. As already mentioned, the armies in all the developed countries are focusing significant attention on developing and upgrading air defense of ground troops. Air defense missile systems, supplemented by light ADA and fighter interceptors, are the primary active air defense weapons. Diverse electronic equipment is used to support their combat operations and to provide command and control: surveillance radars, air defense missile guidance equipment, GCI equipment, ADA fire control systems and electronic equipment for command and control of air defense units and formations. All of this equipment is united in an air defense system which is organized in accordance with the objective and nature of the operation (battle) being conducted by the army.

The development and upgrading of air defense of ground troops is proceeding in various directions depending upon the specific mission for a particular air defense weapon and its role and place in the overall air defense system. Moreover, the primary goal being pursued is to enhance air defense effectiveness for all army combat operations in a difficult environment.

In general, the development of air defense of ground troops, in the opinion of foreign military specialists, is characterized by the following basic trends:

--Giving it properties so it is not just defense against aircraft but also against missiles, i.e., so it will not only be able to counter air-breathing platforms but also tactical missiles;

--Giving it an all-weather, day-night capability to successfully destroy low and very low altitude targets with a concomitant increase in its capability to counter targets at other altitudes;

--Improving its protection against ECM, thermal noise and antiradiation missiles and increasing its effectiveness, mobility and reliability;

--Looking for more feasible organizational structures, air defense combat employment methods and command and control using higher quality automated systems.

As far as specific types of air defense weapons are concerned, these general trends appear more or less strongly while maintaining the total, overall direction.

The process of upgrading air defense is inseparably linked to the process for developing offensive air weapons which naturally leads to an increased role for air defense and to expanding and complicating its missions.

All of this requires continual, systematic study of all the achievements in military science and technology for a field of military affairs like air defense and it requires a high level of vigilance from the men in air defense.

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